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LOCATION OF SITE OF UPPER GASTROINTESTINAL TRACT HEMORRHAGE BY THE FLUORESCEIN STRING TEST

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THERE is need for a safe and rapid method of locating the bleeding site in cases of upper gastrointestinal hemorrhage. The fluorescein string test, originally described by Traphagen,[18] represents an improvement over both the Einhorn[7] string test and a subsequent modified string test described by Rappaport.[16] Experience with the fluorescein string test indicates that this technique makes possible rapid and accurate location of the site of bleeding in upper gastrointestinal hemorrhage.[10, 11] The fluorescein string test differs from the better-known Einhorn string test in that it not only permits location of the bleeding site, but also indicates whether or not there is active bleeding in the area traversed by the string at the time of the test. Because a radiopaque string is used, any gross abnormality of the upper gastrointestinal tract that may be present is likely to become apparent when the roentgenogram of the abdomen (taken routinely as a part of the procedure) is examined.

This paper describes the method for performing the fluorescein string test and reports experience with its use over a 16-month period at St. Luke's Hospital in New York, as well as more recent experience with it at the New York Hospital.

MATERIAL AND METHOD

Subjects.—Eighty-three patients from the ward services, outpatient department, and private service of St. Luke's Hospital and the New York Hospital served as subjects for this study. Patients were selected on the basis of history, clinical signs, and/or laboratory evidence suggestive of recent upper gastrointestinal tract bleeding. In many cases the only evidence of bleeding was the presence of persistently guaiac-positive stools.

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Materials.—The string used in the test consisted of cotton umbilical tape one-fourth inch wide and 5 feet long, containing a radiopaque monofilament* which extended its entire length. Single strands of monofilament were sewn (or glued) at 1-inch intervals horizontally across the tape. Triple strands of monofilament were applied horizontally at 12-inch intervals. Overlapping ends of the horizontally placed monofilaments were trimmed. A second tape was sewn to the first, covering the monofilament markers and providing smooth surfaces. Two milliliters of mercury was placed in a latex finger cot and the opening of the finger cot was tied firmly with surgical silk. For further security, the mercury-containing finger cot was placed in a second finger cot. The outer finger cot was tied to the end of the tape with surgical silk. A knot in the end of the tape prevented it from slipping out of the finger cot.

Fluorescein U.S.P. (5 per cent processed with sodium bicarbonate) is chemically related to phenolphthalein. It emits a yellow fluorescence under ultraviolet light and distributes readily in the extracellular fluid when given intravenously.[9, 14] Many diagnostic uses of this dye have been reported since use of it was first reported in a test for renal function by Strauss in 1913.[4-6, 12, 13, 15, 17] No untoward side effects have been reported.[9, 14] Any ultraviolet lamp can be used to test for fluorescence on the string.

Procedure.—The patient preferably should not have taken anything by mouth for 2 hours before the test. The purpose of the test was explained to the patient immediately before the procedure. The string was allowed to soak in ice water for a few minutes during this interval. The patient was then instructed to swallow the mercury bag with the string attached, with the aid of sips of water. Once the bag was in the stomach, the patient was instructed to continue to swallow small segments of the string. Usually the bag and attached tape had progressed to the region of the ligament of Treitz within 2 to 3 hours. A roentgenogram of the upper abdomen then clearly outlined the characteristic "C loop" of the duodenum. While the patient was lying on the x-ray table, 20 ml. of fluorescein† was injected into an antecubital vein. The dye was allowed to circulate for 4 minutes before removal of the string from the patient's mouth. Gloves were worn prior to withdrawal of the string in order to reduce the danger of dye-contaminated fingers touching it. After the string was removed, it was examined for fluorescence under ultraviolet light.‡ If the patient had been bleeding actively at the time of the test, both blood and dye were found on the tape. The dye was visible as a yellow spot of fluorescence on the tape when examined under ultraviolet light.

Localization of the Site of Bleeding.—The monofilament marker nearest the dye on the tape was noted by counting back the number of inches from the mercury bag. The comparable marker was found on the roentgenogram by counting back the same number of inches from the bag. This marker represented the site of bleeding with an error of not more than 1 to 2 inches.

*Available commercially from Laboratory Associates, 517 Milltown Road, New Brunswick, N. J.

†Supplied by C. F. Kirk Co., New York, N. Y., in 10 ml. ampules.

‡Inspectolight ultraviolet lamp supplied by Englehard Industries, Inc., Hanovia Lamp Division, Newark, N. J.

RESULTS

Eighty-three patients with clinical findings suggestive of recent upper gastrointestinal hemorrhage were examined by means of the fluorescein string test. As shown in Table I, there were 51 patients in Group A (actively bleeding at the time of the test as indicated by both blood and dye on the string). Further information concerning the 51 patients is given in Table II. There were 16 patients in Group B (blood but not fluorescence found on the tape).

TABLE I

FINDINGS	INTERPRETATION	NO. CASES
Group A, blood present, fluorescence present	Active bleeding in the area traversed by string at time of test	51
Group B, blood present, no fluorescence	Bleeding has occurred in area recently, no active bleeding in area traversed by string at the time dye was injected	16
Group C, no blood, no fluorescence	No recent or active bleeding in the area traversed by the string	9
Group D, technically incomplete	—	5
Group E, apparently falsely positive	String contaminated by dye on fingers, no lesion found at indicated site of operation	2
	Total	83

TABLE II

SITE AND SUBSEQUENT SOURCE OF BLEEDING*	NO. CASES
Esophagus	
Esophageal varices	8
Esophagitis	1
Stomach	
Hiatal hernia	5
Stomach ulcer	4
Acute gastritis	2
"Stress ulcers"	4
Duodenum	
Peptic disease	19
Marginal ulcer	4
Miscellaneous	
Thrombocytopenic purpura	2
Uremia	1
Meningococcic meningitis (Cushing's ulcer)	1
Total	51

*All cases except those classified as miscellaneous and 4 cases of "stress ulcer" were confirmed by barium studies, endoscopy, operation, or postmortem examination.

In this group, it was believed that bleeding had occurred recently in the area but that the patient was not actively bleeding at the time of the test. Nine patients were in Group C (no blood or fluorescence found on the tape). Evidence for continued bleeding in the latter cases suggested that the site was distal to the tape. Group D consisted of 5 patients in whom tests were technically incomplete. Progress of the bag was halted in these patients for various reasons, such as complete obstruction from massive esophageal and gastric varices, huge hiatal hernia, and intestinal ileus in a terminal patient. Group E consisted of 2 patients with apparently false-positive results. The first mistake was thought to have been caused by an error in technique in which dye had rubbed off on

the string while it was being withdrawn from the patient's mouth. This resulted in a false location of the bleeding site. The bleeding point was shown to be in the upper stomach in the other apparently false-positive test. At operation the true site of bleeding was found to be in the lower esophagus.

Table II lists the various sites and lesions that were subsequently found by barium studies, at operation, postmortem examination, or endoscopy in patients of Group A (those who were actively bleeding at the time of the test). The 5 patients with hiatal hernia had evidence of chronic, low-grade blood loss, and the ages of these patients ranged from 51 to 68 years. Of special interest were 4 cases of hematemesis that occurred suddenly in elderly women with no known previous gastrointestinal tract symptoms. Each of the women had recently sustained a fractured hip. The bleeding was of short duration in all of these patients and lasted only a matter of hours. Subsequent roentgenograms of the upper gastrointestinal tract, taken several days to a few weeks later, were negative. These patients apparently bled from "stress ulcers."[2] There were 2 cases of thrombocytopenic purpura and 1 case of uremia, as well as 1 of meningococcic meningitis in which multiple heavy concentrations of dye were highly suggestive of multiple bleeding sites extending from the midesophagus to the pylorus. In the latter cases, all bleeding stopped when the underlying condition was corrected. No lesion could be demonstrated by barium studies performed some time after the respective conditions had improved. Confirmation of the bleeding site, as determined by the fluorescein string test, was obtained in all of the remaining cases by subsequent barium studies, operation, endoscopy, or postmortem examination.

The rapid intravenous administration of fluorescein resulted in transient nausea and vomiting in 2 cases. No other significant side effects were noted. A yellow color of the skin and urine persisted in all patients for several hours after the test.

DISCUSSION

The fluorescein string test has accurately located the bleeding site in cases of acute and chronic blood loss from the upper gastrointestinal tract. In cases of acute hemorrhage, the test may be accomplished with the aid of a portable x-ray unit at the patient's bedside. It has proved to be of particular value in patients with chronic occult bleeding from the upper gastrointestinal tract. Despite the use of barium studies and endoscopy, it is frequently impossible to demonstrate a bleeding site in many patients with upper gastrointestinal tract hemorrhage. In some, two or more suspicious sites are demonstrated on the routine gastrointestinal tract x-ray studies. The fluorescein string test has been especially helpful in distinguishing the source of bleeding in these patients. Patients with cirrhosis of the liver who have upper gastrointestinal tract hemorrhage often present a difficult problem in diagnosis. The bleeding may be due to esophageal varices or another source distal to the esophagus, that is, peptic disease or alcoholic gastritis. Most methods currently used to locate bleeding in such cases either are dangerous or difficult for the average physician to perform (endoscopy), or give only indirect information (measurement of Bromsulphalein retention or blood ammonia concentration).[8] The practice of

passing the Blakemore esophageal balloon in these patients entails definite risks, especially when varices have not been proved and the existence of portal hypertension is in doubt.[1] An abbreviated string test has been found useful in such cases. The patient swallows the string and after the presence of the string in the stomach has been ascertained by x-ray studies, the dye is injected and the string withdrawn 4 minutes later. If dye is found on the string, the bleeding is from the esophagus, and varices may be considered the cause.

The following 3 cases illustrate the usefulness of the fluorescein string test in detecting the exact site of upper gastrointestinal hemorrhage.

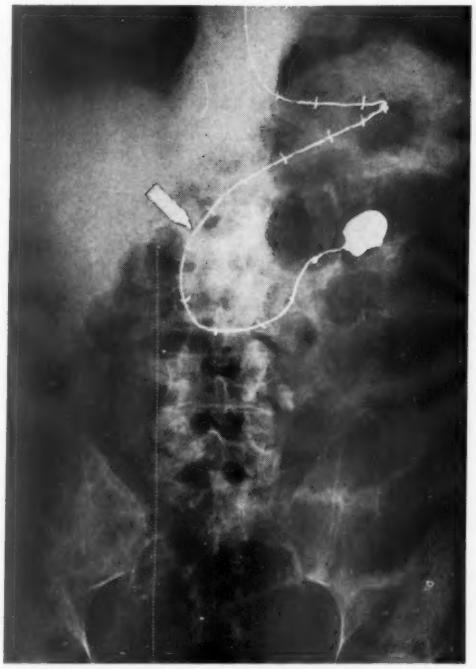

Fig. 1.

CASE REPORTS

CASE 1.—A 20-year-old Puerto Rican man was admitted to St. Luke's Hospital complaining of weakness. He had passed one tarry stool the day preceding admission and had noticed dull upper midepigastric pain relieved by food or alkali over the previous 2 months. Results of physical examination were within normal limits, and the man was in no acute distress. The hemoglobin count was 11 Gm. per cent and the results of stool examination were strongly positive for blood. A fluorescein string test performed soon after admission revealed active bleeding at the time of test, and the bleeding point was located at the duodenal bulb (Fig. 1, arrow). An upper gastrointestinal series performed subsequently demonstrated an ulcer crater in the duodenal bulb. The patient was discharged about 3 weeks later after a follow-up x-ray study had revealed clearing of the ulcer. The patient had been admitted during the night and by means of the fluorescein string test the bleeding site had been located within 2 hours.

CASE 2.—The fluorescein string test was performed on a 56-year-old Puerto Rican woman in the outpatient department of St. Luke's Hospital. For several years, the patient had noted intermittent weakness associated with tarry stools. The abnormality found on many previous roentgenograms was a large hiatal hernia. The patient was told to bring a stool specimen to the clinic the day of the proposed test. The stool specimen was strongly positive

for occult blood. The string test indicated that the bleeding site was in the region of the hiatal hernia (Fig. 2, arrow). The hiatal hernia was subsequently repaired, and the woman had no further signs or symptoms of blood loss.

CASE 3.—A 64-year-old white nurse's aid was seen in the outpatient clinic complaining of weakness and persistent nonproductive cough of 2 weeks' duration. Eight years previously, she had undergone a subtotal gastrectomy with gastrojejunostomy for benign gastric ulcer. Since operation, the patient was noted to have had chronic intermittent gastrointestinal bleeding. She had been admitted to the hospital 5 years previously because of weakness and guaiac-positive stools. A complete investigation for the site of bleeding had given negative results at this time. She had received iron therapy subsequently for her "iron deficiency anemia" without sustained benefit and was admitted again for examination.

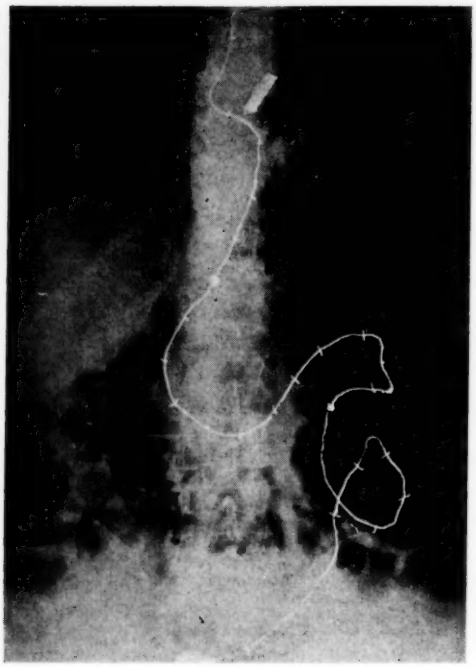

Fig. 2.

Fig. 3.

Physical examination revealed a pale white female in no acute distress. Vital signs were normal. Coarse râles were heard at both lung bases posteriorly, and the epigastrium was moderately tender on palpation. The remainder of the results of physical examination were within normal limits. Hemoglobin concentration was 9.3 Gm. Repeated stool guaiac tests varied between 1 plus and 4 plus. The râles in the chest cleared after antibiotic therapy. Roentgenograms of the upper and lower gastrointestinal tract and proctoscopy failed to disclose the bleeding site. Laboratory examination showed no blood dyscrasia. The fluorescein string test indicated that the bleeding site was in the region of the gastrojejunostomy (Fig. 3, arrow). The diagnosis of bleeding marginal ulcer was made, and the patient was placed on an ulcer regimen. The bleeding soon stopped, as indicated by consistently guaiac-negative stools, and the patient was discharged with a hemoglobin concentration of 12.8 Gm.

This case illustrates the usefulness of the string test in locating the site of bleeding in a patient with chronic, low-grade bleeding where the usual methods of diagnosis had been of little or no help.

SUMMARY AND CONCLUSIONS

1. The fluorescein string test is a recently described method for locating the site of upper gastrointestinal hemorrhage. This test is superior to the earlier

Einhorn string test because it not only permits rapid and precise location of the bleeding site but also makes it possible to determine whether or not active bleeding is occurring in the upper gastrointestinal tract at the time the test is performed.

2. Results obtained with the fluorescein string test in 83 cases of upper gastrointestinal hemorrhage have been summarized. Three case reports illustrate its usefulness.

3. Of 83 patients examined, 51 were actively bleeding at the time of the test. With the help of the fluorescein string test, accurate location of the site of bleeding was made in all members of this group.

We are indebted to Dr. Theodore Van Itallie, Director of Medicine, St. Luke's Hospital, for his many helpful suggestions in the preparation of this paper. We also wish to thank Mrs. Daly and Mrs. Wilgohs of the Sewing Department of this hospital for making the strings used for the test. We thank the x-ray departments of both hospitals for their cooperation, as well as Miss Inez Alvarez for typing the manuscript.

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CANCER OF THE ARTIFICIAL ESOPHAGUS: PARTIAL RESECTION AND ESOPHAGEAL REPLACEMENT BY TRANSPLANT FROM THE ILEUM

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ONLY recently have reports of carcinoma developing in the skin lining of an artificial esophagus appeared. Picot[6] described the case of a patient in whom Roux had constructed, from 1906 to 1911, a substitute esophagus made of jejunum and a small segment of cutaneous tube. The replacement had been satisfactory for 30 years when a cancerous fistula developed in the skin tube. The patient was subjected to radiation and his ultimate fate is unknown. In 1957, Scheibe[8] reported a similar case of cancer developing 38 years after an esophageal reconstructive operation. The cancer was not recognized until a fistula occurred and the patient eventually died of liver failure. A more exhaustive study was given by Lebsche and Schopp,[5] who reported a case of squamous cell cancer developing in a skin tube esophageal replacement 32 years after it had been made. A radical operation cured the lesion, but attempts at reconstruction were unsuccessful and the patient was forced to feed himself through a rubber tube inserted into the distal segment of the artificial esophagus.

We have observed 2 such cases in the Third Surgical Clinic of the Medical Academy in Wroclaw.

CASE REPORTS

CASE 1.—A 50-year-old woman had sustained a caustic burn of the esophagus. Thirty-one years ago, a substitute esophagus was formed according to Yianu and Rutkowski[7] by Dengel.[1] The operation consisted of 4 stages and took 3 years and 2 months to complete. Afterward, the patient subsisted mainly on liquid food, since solids were retained in the cutaneous part of the esophagus and entered the stomach only with massage. In addition, she regurgitated frequently after eating, particularly when in the recumbent position. From the very beginning, she had experienced periodic burning and itching in the cutaneous part of the esophagus just above the gastric anastomosis.

By 1950 the symptoms had increased, with occasional reddening of the skin covering the cutaneous gullet. By the end of 1956, edema and swelling of the skin had become constant, with gradual extension to the level of the manubrium. When pain became severe, the patient sought medical aid and was told to apply packs. In April, 1957, a fistula developed in the middle portion of the artificial esophagus. A second fistula appeared 1 month later and nutritional difficulties increased until the patient was no longer able to feed herself. She was first seen at this clinic on Dec. 4, 1957.

On admission, the patient was poorly nourished and had a bulge on the left side of the neck corresponding to the cutaneous tube of the artificial esophagus. At the level of the

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manubrium, the wall of the artificial esophagus was thickened, indurated, tender, and bluish red. In the distal part of this segment, 3 cm. apart, were 2 fistulas surrounded by proliferating neoplastic tissue (Fig. 1). The patient was nourished with liquids via a catheter passed through the lower fistula into the stomach. There were no other abnormal findings in the thoracic or abdominal organs. Results of laboratory examination of the blood and urine were within normal limits.

An x-ray study of the chest showed moderate emphysema of the lungs and primary calcification of the middle portion of the right lung. The heart was of normal size with an accentuation of the aortic arch. A swallowed barium meal filled the cervical part of the esophagus up to the level of the fourth trachcal cartilage. At this level there was a diverticulum-like bulge. Slightly above the bulge, the contrast medium passed through the anastomosis into the cutaneous tube which was fairly wide at the level of the manubrium.

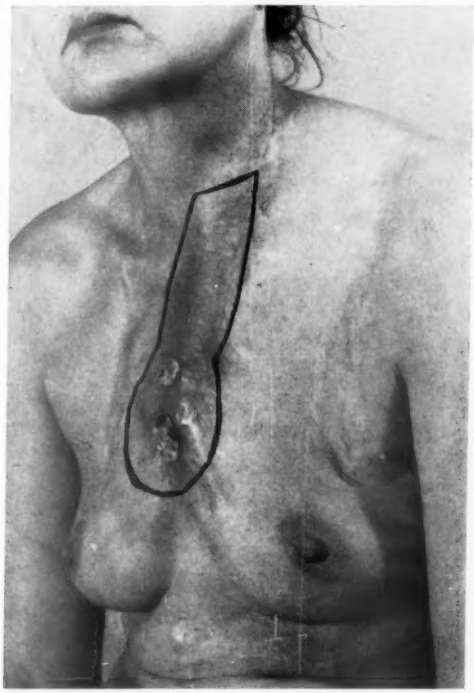

Fig. 1.—Patient in Case 1 with cancer of the artificial esophagus. The bulging esophagus is visible on the neck and chest. Its middle portion shows neoplastic lesions. The area of radical resection is marked with the continuous line.

However, beginning at this site, it narrowed to 0.5 cm. in diameter. Only a small portion of the meal reached the distal segment of the esophagus because most of it leaked through the fistula. At the level of the xiphoid process, the esophageal tube was wider and the folds of its mucous membrane were visible. The barium entering the stomach filled first the antrum, then the middle and upper part, with free passage from the stomach to the duodenum. Biopsy of the fistula showed a squamous cell carcinoma with tendency to keratinization.

On Dec. 21, 1957, an operation was performed under endotracheal ether-oxygen anesthesia. The abdomen was opened through an upper medial abdominal incision. A gastric tube, 7 cm. long, was dissected from the thoracic subcutaneous tissue and mobilized to about 4 cm. below its anastomosis with a skin tube. It was transected at this point and the neoplastic growth was radically excised. Thereafter, the distal part of the ileum was mobilized with preservation of its blood supply by the ileocolic vessels. The proximal mesenteric vessels were divided at a level which allowed the mobilized intestines to be brought up into the cervical region. Vascular arcades in the ileum were divided at the same level. Then the arcades between the ileocolic vessels were interrupted after the ascending colon

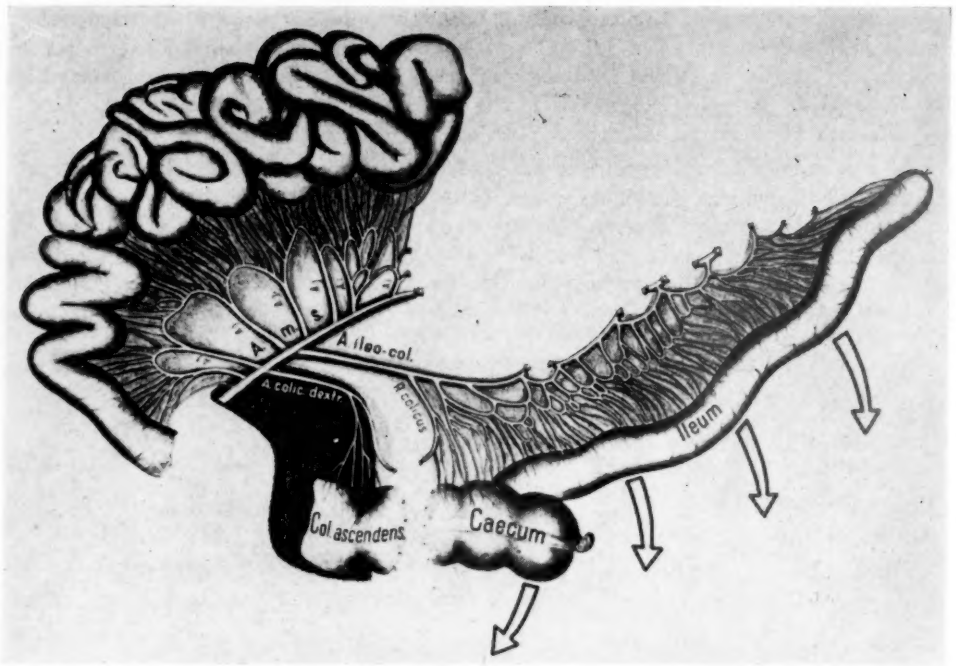

Fig. 2.—Technique of mobilization of cecum and ileum. The mobilized intestine is suspended on the ileocolic artery. The arrows show the direction of the displacement of the mobilized intestinal segment.

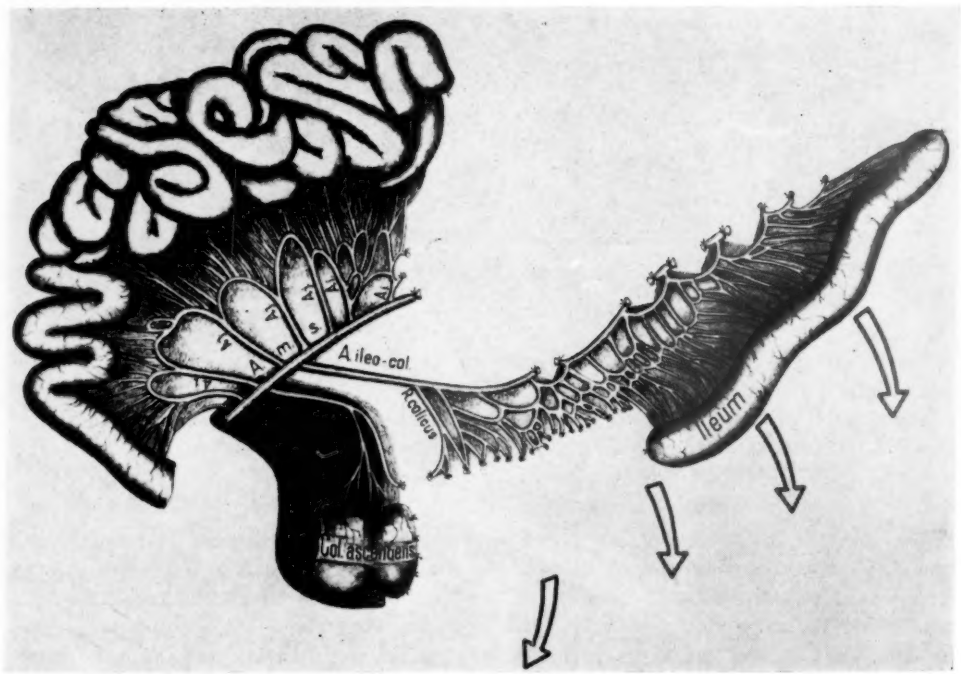

Fig. 3.—Construction of the transplant from the ileum. Segment of ileum is suspended on the ileocolic artery.

had been divided and the stumps closed. The mesenteric edge of the mobilized ileum was elongated by the division of some multiform vascular arcades (Fig. 2). The cecum along with the adjacent part of the ileum, about 15 cm. long, was well mobilized by ligation of the mesenteric vessels close to the walls (Fig. 3). The mobilized segment of the ileum was passed through openings in the transverse mesocolon and the gastrohepatic ligament, and its efferent end was anastomosed to the gastric tube. The mobilized ileum was then passed into a retrosternal canal and the small portion of the cutaneous artificial esophagus was anastomosed to the efferent end of the ileum. To restore continuity of the gastrointestinal tract, a side-to-side anastomosis was formed between the ileum and the transverse colon (Fig. 4).

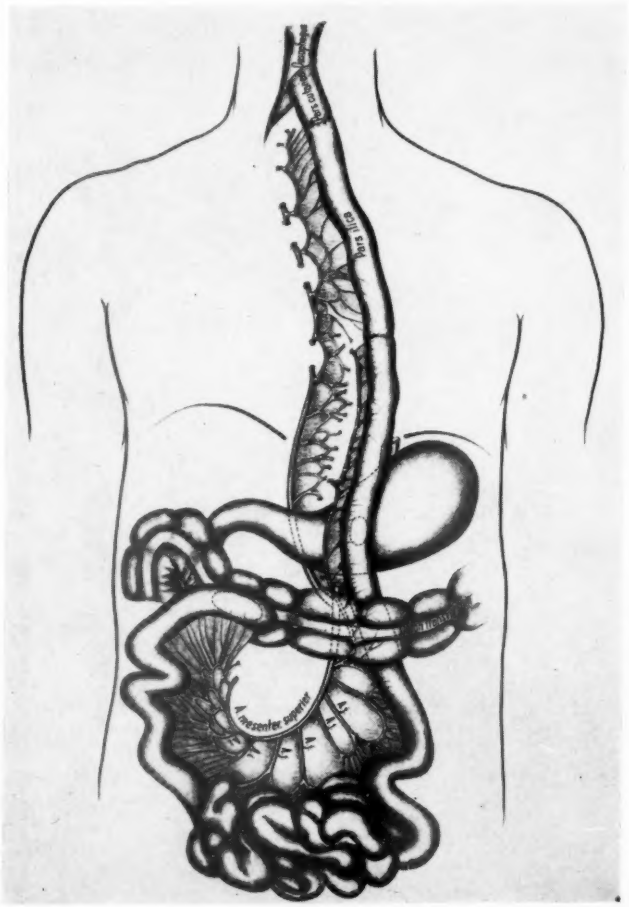

Fig. 4.—Partial reconstruction of the artificial esophagus by means of the transplant from the ileum. The stump proximal to the intestinal transplant is anastomosed to a small segment of the cutaneous part of the esophagus in the cervical region. The distal stump is anastomosed to the gastric tube.

The thoracic wounds were closed and gastrostomy was instituted in the anterior wall of the stomach. The abdominal wound was closed around the feeding tube. In the postoperative period, the patient was given blood and protein replacement intravenously. During the first 6 days, she received penicillin and streptomycin and then Aureomycin and Terramycin. Except for a slight separation around the feeding tube, the wounds healed spontaneously. On the tenth postoperative day, the patient was started on fluids and was gradually allowed solid foods (Fig. 5). Radiologic examination performed on Jan. 8, 1958, showed the barium meal passing freely through the new esophagus (Fig. 6).

Examination of the surgical specimen demonstrated an ulcer 5 cm. long in the skin portion of the artificial esophagus just above the gastric anastomosis (Fig. 7). In the

external skin covering of the artificial esophagus there were 2 fistulas surrounded by proliferating neoplastic tissue. Histologic examination of this tissue revealed a characteristic squamous cell carcinoma with tendency to keratinization.

CASE 2.—A 62-year-old woman had suffered a caustic burn in the esophagus from the mistaken ingestion of ammonia. Two weeks afterward, the stricture of the esophagus had become complete. Attempts were made to dilate the stricture, and during one of these procedures perforation of the wall of the esophagus with right pneumothorax occurred. The patient was admitted to one of the hospitals in Warsaw. Gastrostomy was performed and the patient fed herself through it for 17 years. In 1936, a substitute esophagus was constructed of the jejunum and a skin fuse (Military Hospital, Warsaw). The operation was carried out in several stages within a 3-year period. The patient fed herself initially with liquids and progressed to solid foods. In April, 1940, the gastrostomy was closed. In

Fig. 5.—The patient in Case 1 after operation. The skin of the chest exhibits extensive scars after radical resection of cancer of the antethoracic esophagus. The new esophagus, constructed partially by means of the transplant from the ileum, was transferred into the anterior mediastinum.

1943 the woman began to experience itching and burning sensations in the lower segment of the cutaneous part of the esophagus. The sensations increased, particularly at night when she was in the recumbent position. At times they were so annoying that the patient resorted to artificial massage and scratching the covering skin. This led to ulceration of the skin of the artificial esophagus. She eventually sought relief at a hospital in Warsaw. Her symptoms were attributed to irritation by hair growing within the cutaneous part of the artificial esophagus. Irradiation was instituted to halt the hair growth, but the treatment did not relieve the symptoms. By 1959, bleeding from this portion of the artificial gullet occurred.

On admission to this clinic, the woman was severely ill and poorly nourished. On the anterior surface of the chest there were extensive scars and hyperpigmentation of the skin corresponding to the bulge in the esophagus. The cutaneous tube of the artificial esophagus

was thickened, fairly firm, and tender on palpation. Just above the anastomosis with the intestine, a firm, tender 2 cm. nodule was palpable. The overlying skin was movable. Laboratory examination showed an elevated erythrocyte sedimentation rate, normal blood and urine results, and normal results of bleeding tests. Electrocardiogram was suggestive of a myocardial lesion. Radiologic examination showed a normal chest film. Anteroposterior and lateral projections taken after barium ingestion showed a filling defect in the

Fig. 6.—Roentgenogram of the artificial esophagus. The cervical region shows the cervical part of the natural esophagus, small segment of the new esophagus constructed by means of the cutaneous tube, and the retrosternally situated small intestine.

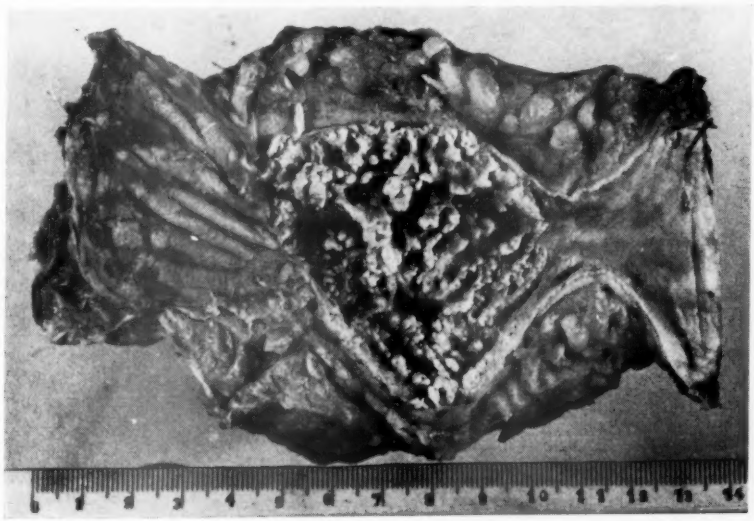

Fig. 7.—The excised part of the artificial esophagus with neoplastic lesions. The ulceration area with uneven bottom, covered with tissue strands, is sharply delimited from the gastric mucous membrane. On the right is the skin lining the artificial esophagus.

distal segment of the substitute esophagus. The anastomosis between the cutaneous tube and the small bowel was very narrow and orally administered barium was retained temporarily within the cutaneous tube.

On Nov. 14, 1959, the patient was operated upon under endotracheal ether-oxygen anesthesia. The peritoneal cavity was opened through an upper midline abdominal incision reaching from the xiphoid process to the umbilicus. The cutaneous tube with neoplastic lesion was dissected free and excised. The efferent stump of the ileum was anastomosed to that of the jejunum and the afferent one to the cervical esophagus (Fig. 8). This

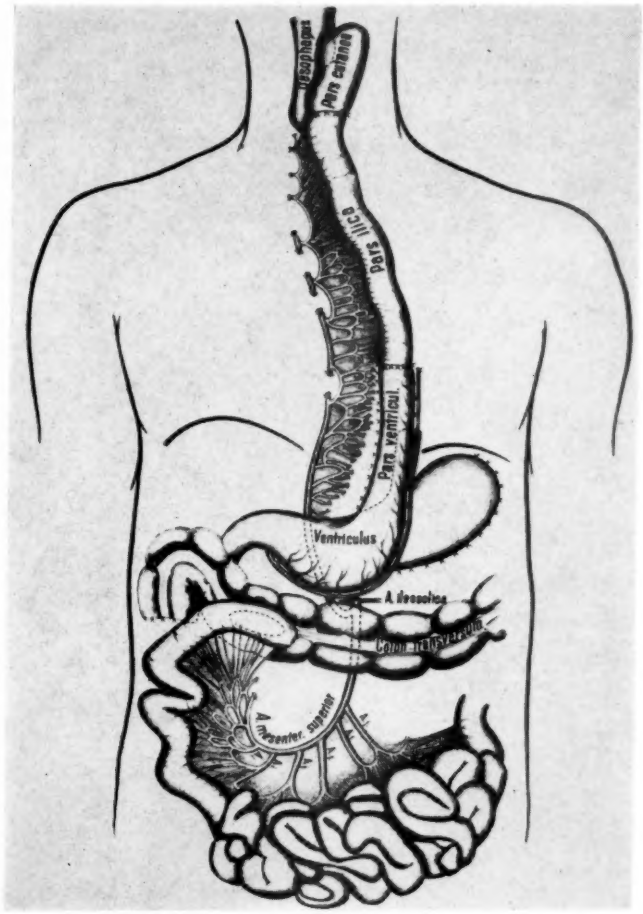

Fig. 8.—Partial reconstruction of the artificial esophagus by means of a transplant from the ileum.

newly constructed esophagus was covered with the skin from the anterior surface of the chest. Gastrojejunostomy was instituted in the anterior wall of the stomach. The abdominal wall was closed in layers. After operation, blood, protein, and intravenous saline and glucose were given. Antibiotics were administered for the first few days. By the fifth postoperative day, a cervical fistula had developed which healed within 2 weeks. Later, a stricture was found at the same site. With local anesthesia, the scar was excised and the cervical anastomosis widened. This wound healed per primum, and the patient can tolerate all foods at the present time (Fig. 9).

Grossly, the skin lining of the resected part of the esophagus showed multiple papillae with numerous hemorrhages. Three centimeters above the jejunal anastomosis, a 1 cm.

nodule was visible on the lateral posterior wall. In the center of this nodule was an ulcerated area (Fig. 10). Histologic examination of the nodule revealed squamous cell carcinoma. Examination was made of the skin sections excised at various levels.

Fig. 9.—Photograph of the patient in Case 2 after radical resection of cancer of the artificial esophagus and replacement of the defect by means of a transplant from the ileum.

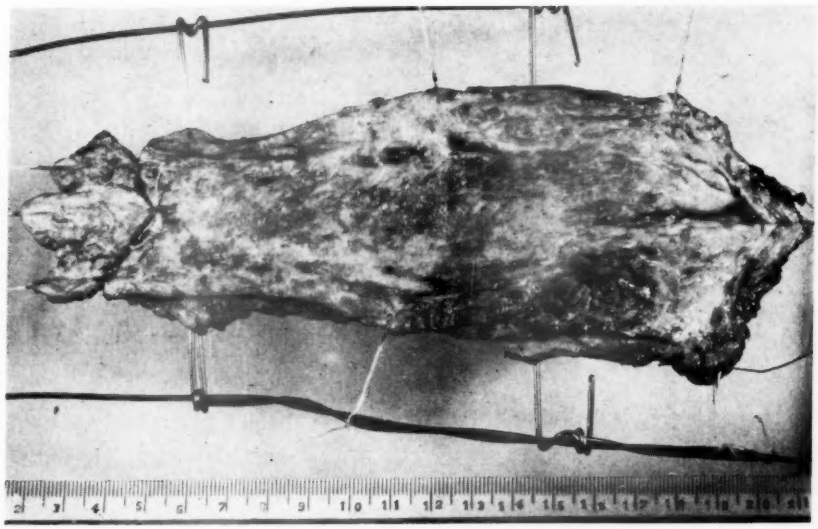

Fig. 10.—The skin lining the excised part of the cutaneous tube. In the lower part on the left is the neoplastic tumor, the size of a plum, with ulceration showing an uneven bottom.

Upper Segment.—The epidermis was approximately 1 mm. thick and the cutis produced numerous thin papillae which herniated deeply into the epidermis. Blood vessels were often visible at the axis of the papillae. The glands were either lacking or had a structure suggestive of rudimentary secretory segments of the sweat glands (Fig. 11).

Middle Segment.—The epidermis was approximately 700 μ thick. In the layer corresponding to the subcutaneous tissue there were distinct globules of fat tissue. In some places, the cutis showed cellular infiltrates under the epidermis (Fig. 12).

Lower Segment.—The general structure was similar to that of the upper and middle segments except the epidermis was somewhat thicker (1.5 mm.) and in the layer corresponding to the subcutaneous tissue there were fairly numerous bundles of smooth muscle fibers.

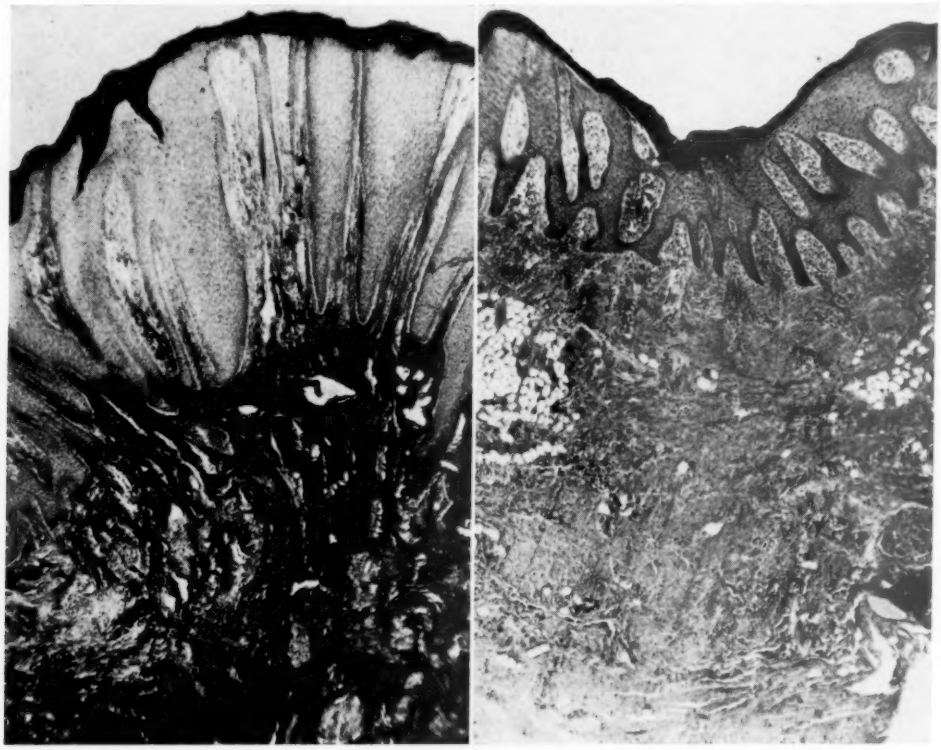

Fig. 11. Fig. 12.

Fig. 11.—Photomicrograph of the histologic preparation from the skin lining the new esophagus 30 years after reconstructive operation. The stratum spinosum and basal cells exhibit varying degrees of nuclear disintegration which suggests an abnormal and rapid proliferation of the nuclear substance.

Fig. 12.—Photomicrograph of the skin lining the artificial esophagus. Small cellular infiltrates are crowded beneath the epidermis.

DISCUSSION

With the introduction of the skin as a lining for a substitute esophagus, many surgeons anticipated that it would adapt readily to its new task. This has not been the case. Gradually pathologic changes occur in both the epidermis and cutis and frequently a neoplastic lesion eventually occurs in the cutaneous portion of the artificial esophagus. In the 2 patients whose cases are reported here and in those reported elsewhere, the neoplastic lesions occurred

in the cutaneous part of the artificial esophagus, which would suggest a predilection of cancer to this site. In addition, there has been no report of patients with the esophagus constructed from the intestine and cutaneous tube who have survived more than 30 years without developing neoplastic lesions. Such lesions are connected undoubtedly with the influence of nonphysiologic stimuli (all types of foods, saliva, and stomach content) on the skin. Clinical observations do not warrant the recognition of a single causative factor. In our cases, it was probably the gastric juice, as suggested by the localization of the lesions in the cutaneous tube above the gastric anastomosis in one case and above the jejunal anastomosis in the other case. In the latter instance, the jejunal segment was extremely short.

The diagnosis of cancer of the cutaneous esophagus presents no difficulties. The mere fact that it occurs 17 to 30 years after the completion of the reconstructive operation is of importance as a diagnostic feature. Symptoms such as itching, burning, or bleeding from the artificial gullet are an indication of changes which precede the occurrence of the neoplastic process. The finding of a thickening or nodule of the cutaneous tube along with these symptoms should establish the diagnosis. When the neoplastic process has involved the skin and has given rise to the formation of fistulas, the diagnosis becomes evident. Radiologic examination of the artificial gullet is helpful, particularly if a filling defect is present. The most effective treatment of cancer of the cutaneous esophagus consists of a radical resection and reconstruction of esophageal continuity by means of an ileal transplant. It would seem that the use of skin in reconstructive operations of the esophagus, however, should be condemned. The same results can be accomplished with an intestinal replacement without the hazard of cancer development at a future time.

SUMMARY

Two cases of carcinoma occurring in the cutaneous portion of an artificial esophagus are presented. The possibility of gastric juice as an irritant and causative factor in these cases is discussed. The treatment of the disease (radical resection of the carcinoma and reconstruction of the esophagus with a mobilized portion of the ileum) is described. The use of a skin tube as replacement for the esophagus is condemned.

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USE OF THE TRANSPOSED ILEOCECAL VALVE FOR SPHINCTERIC CONTROL OF GASTRIC EMPTYING AFTER ABLATION OF THE PYLORUS

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THE normal mechanisms of gastric digestion are dependent upon the integrity of the pyloric sphincter. After gastrectomy, gastroenterostomy, or pyloroplasty the pattern of gastric emptying is altered. Absence of the pyloric sphincter apparatus is in part responsible for certain postgastrectomy conditions (dumping syndrome, fat malabsorption, incessant diarrhea, anemia, and so forth) which sometimes result from abnormally rapid transit of chyme through the gastrointestinal tract.[1, 7, 8] The purpose of this study is to evaluate experimentally the feasibility of the utilization of another gastrointestinal sphincter, the ileocecal valve, for the control of gastric emptying after destruction of the pyloric sphincter.

METHOD

Unselected healthy adult mongrel dogs were employed in the preparation of 3 groups of test animals. Animals of the control group (Group I) underwent no gastrointestinal operative procedure. A pylorectomy (with excision of an approximately 1 cm. cuff of both distal stomach and proximal duodenum) and gastroduodenostomy were performed in the animals constituting Group II. In the animals of Group III the pylorus was similarly excised. In this group the ileocecal region was mobilized on its neurovascular pedicle by division of the mesoileum proximally and the mesocolon distally. The ileum and the colon were divided in such a way that the ileocecal sphincter was situated in the middle of an isolated 4 to 5 cm. segment of bowel. This ileocecal segment was rotated counterclockwise on its pedicle and swung into interposition between the separated stomach and duodenum in an isoperistaltic manner. Appropriate anastomoses were made to re-establish gastrointestinal continuity (Fig. 1). Splenectomy was performed in certain of the animals in each of Groups I, II, and III.

All surgical procedures were carried out by sterile operative techniques and veterinary Nembutal (30 mg. per kilogram) was used for anesthetization. Midline laparotomy incisions were employed and all bowel anastomoses were performed end-to-end with an inner row of continuous No. 3-0 catgut sutures and an outer row of interrupted No. 4-0 silk seromuscular sutures.

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Early in the study routine preparation and postoperative management of the animals with ileocecal sphincter transposition included the preoperative administration of castor oil and Sulfasuxidine (succinylsulfathiazole) combined with the use of cleansing enemas for bowel preparation. No postoperative antibiotic coverage was practiced. This regimen was abandoned because of the poor survival rate obtained. The definitive plan of preoperative management of Group III animals was somewhat different. All animals were given nothing by mouth for 24 hours prior to operation. Postoperatively oral feedings were restricted and the animals were maintained on a regimen of daily intravenous fluids and intramuscular antibiotics (procaine penicillin, 300,000 U., and streptomycin, 0.5 Gm.) for 5 days. After 5 days no special precautions were taken and the animals were fed standard kennel rations.

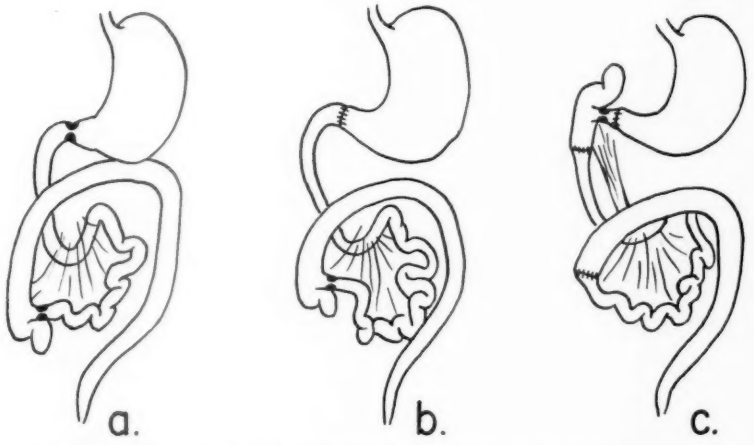

Fig. 1.—Schematic drawing of the gastrointestinal tract for each group of animals. *a*, Normal (Group I), *b*, pylorectomy (Group II), *c*, ileocecal interposition (Group III).

After a postoperative period of 1½ to 13 months had passed, a gastrointestinal series was performed in each animal. The unanesthetized animal was secured in the prone position and a mixture of barium sulfate in an aqueous solution of glucose (50 per cent weight per volume) was placed in the stomach (in the volume of 25 c.c. per kilogram of body weight) via a long hard rubber tube. (Hypertonic glucose solution was utilized in order to accentuate any secondary or reflex changes of small bowel response produced by the rapid "dumping" of hypertonic gastric contents into the duodenum.[1, 2]) One hour after instillation of the contrast meal a plain roentgenogram of the abdomen was obtained and the animal was returned to its cage. Four and 8 hours after the test meal the animal was again secured and roentgenograms were obtained.

The rate of gastric emptying and progression of the contrast bolus through the intestinal tract were assessed from the roentgenologic findings for each animal.

RESULTS

A total of 9 animals underwent pylorectomy (Group II). There were 2 operative deaths. One animal died on the second postoperative day as a result

of aspiration pneumonitis and the other on the sixth postoperative day as a result of abdominal evisceration. A third animal died 6 months after pylorectomy by exsanguination secondary to delayed hemorrhage from the site of an arteriotomy which had been performed for blood pressure measurement during attempted "dumping" studies. A fourth animal was inadvertently released to a different experimental endeavor 8 months after pylorectomy. Of the total of 9 animals with pylorectomy only 5 remained for late roentgenologic examination.

In Group III only 1 of the 5 animals which had undergone ileocecal transposition early in the study, when antibiotics were not given postoperatively, survived beyond 7 days. However, in the 6 animals which received antibiotics postoperatively there was but a single death after ileocecal transposition. This animal died suddenly as a result of iatrogenic potassium intoxication in the postoperative period of prolonged parenteral alimentation necessitated by stomal obstruction. Necropsy examination of the 5 animals that died in the early postoperative period (12 hours to 24 days) revealed evidence of vascular insufficiency of the transposed ileocecal segment in only 1 instance. In this particular animal there was a small gangrenous area of the transposed colonic segment with perforation (Table I).

TABLE I. COURSE OF ANIMALS WITH REPLACEMENT OF PYLORUS BY ILEOCECAL SPHINCTER

ANIMAL	TIME OF DEATH (POST-OPERATIVE)	CAUSE OF DEATH	STATUS OF ILEOCECUM	ROENTGENOLOGIC EVALUATION
396	3 days	Peritonitis	Viable	No
428*	—	—	Viable	No
459	7 days	Subphrenic abscess and leak at suture line	Gangrenous	No
482	< 12 hr.	Anesthetic narcosis	Viable	No
777	5 days	Pneumonitis and wound abscess	Viable	No
104	24 days	Stomal obstruction and potassium intoxication	Viable	No
48	—	—	Viable	Yes
189	—	—	Viable	Yes
325	—	—	Viable	Yes
481	—	—	Viable	Yes
197	—	—	Viable	Yes

*Animal misplaced 5 months postoperatively.

Thus, including the 5 normal animals of Group I, gastrointestinal roentgenograms were obtained in 15 animals. Roentgenograms obtained by the method described are shown in Figs. 2, 3, and 4. Tabulation of the distribution of the contrast material within the gastrointestinal tract 1, 4, and 8 hours after the barium-glucose meal is presented in Table II. It is evident that there was abnormally rapid gastric emptying in animals of the group which had undergone pylorectomy. On the other hand, the transgastric passage of the meal was normal or slightly prolonged in the animals which had undergone gastroduodenal interposition of the ileocecal sphincter. There was early appearance of barium in the colon in 2 of the group with pylorectomy. However, despite

TABLE II. RELATIVE OPACIFICATION OF STOMACH, SMALL BOWEL, AND COLON 1, 4, AND 8 HOURS AFTER HYPERTONIC BARIUM MEAL

GROUP	STOMACH			SMALL BOWEL			COLON		
	1 HR.	4 HR.	8 HR.	1 HR.	4 HR.	8 HR.	1 HR.	4 HR.	8 HR.
Normal	+++	+++	+	+	+	++	0	0	+++
	+++	+++	+	+	++	++	0	0	+++
	+++	+++	+	++	++	+++	0	0	+++
	+++	+++	+	++	++	+++	0	0	+++
	+++	+++	++	++	++	+++	0	0	+++
Pylorectomy	+++	+	0	++	+++	+	0	0	+++
	+	+	0	+++	+++	+	0	0	+++
	+++	+++	0	++	++	++	0	0	+++
	++	++	0	+++	++	+	0	+	+++
	+++	+++	+	++	++	++	0	+	+++
Ileocecal interposition	+++	+++	+	++	+++	+	0	+++	+++
	+++	+++	+++	++	+	+	0	++	+++
	+++	+++	+	+	++	++	0	++	+++
	+++	+++	++	++	++	+++	0	++	+++
	+++	+++	+	+	+++	+	0	++	++

0 No barium present.
+ Small amount of barium present, lumen not outlined.
++ Moderate amount of barium present, lumen outlined but not solidly opacified.
+++ Large amount of barium present, lumen solidly opacified.

Fig. 2.—Roentgenograms obtained 1 hour after hypertonic barium meal in *A*, normal group, *B*, group with pylorectomy, and *C*, group with ileocecal interposition. Note extreme opacification of the small bowel in animals with pylorectomy.

the delay in gastric emptying there was early appearance of barium in larger amounts in the colon in each of the animals with ileocecal interposition (Table II).

Two or 3 animals of each group had undergone splenectomy. No difference between gastrointestinal transit times for splenectomized and nonsplenectomized animals could be detected in any of the groups.

All 10 survivors (10 to 22 months) of Groups II and III have maintained a healthy appearance and have exhibited progressive weight gains in the postoperative period.

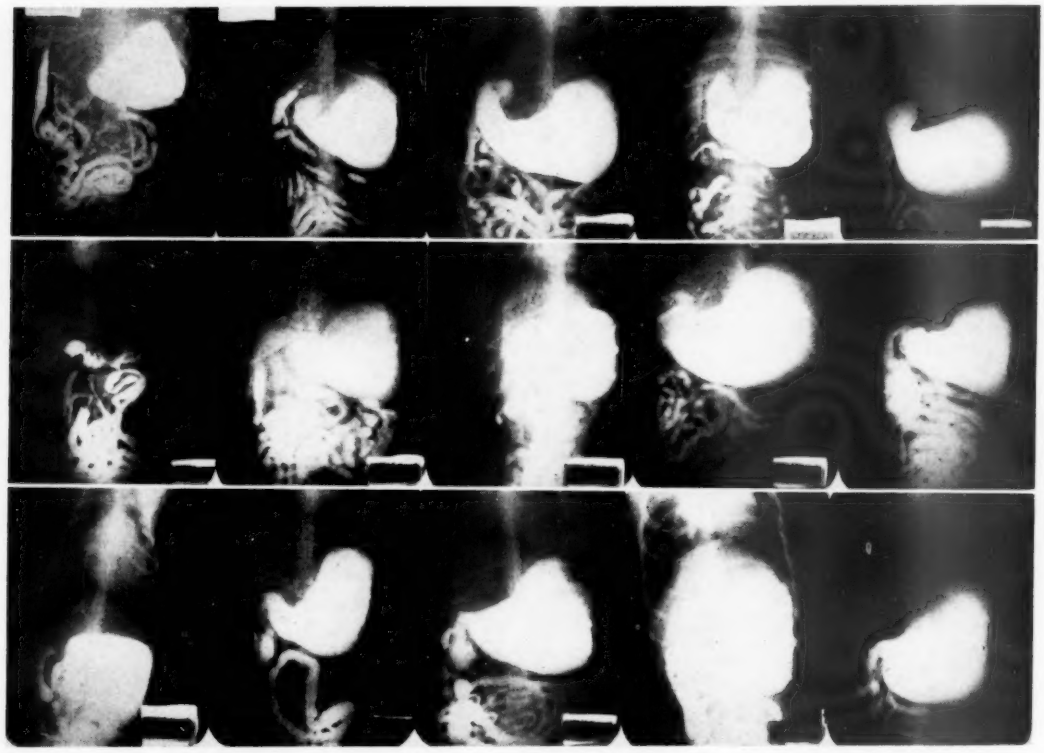

Fig. 3.—Roentgenograms obtained 4 hours after hypertonic barium meal in *A*, normal group, *B*, group with pylorectomy, and *C*, group with ileocecal interposition. Note early gastric emptying in the group with pylorectomy and early appearance of colonic opacification in animals with ileocecal interposition.

DISCUSSION

The intact distal stomach is vital in the control of gastric emptying. With progression of each antral peristaltic wave there is alternate relaxation and spasm of the pyloric region as the stomach contents are churned into the gastric outlet. These orderly changes of muscle tone produce controlled, intermittent emptying of gastric chyme into the duodenum.[1, 8, 11] Surgical ablation of the pyloric sphincter upsets this emptying regulatory apparatus so that the unopposed antral peristaltic contractions and intragastric hydrostatic pressure transport the gastric contents at an abnormally rapid rate into the duodenum.[1, 2, 7, 8] Loss of the pyloric sphincter, although not usually of drastic

consequence, is a factor in the production of certain postgastrectomy phenomena which are related to a shortened gastric emptying time.

In its normal locus the ileocecal junction acts both as a one-way valve which prevents regurgitation of cecal contents into the terminal ileum and as a sphincter which is instrumental in the regulation of the passage of ileal contents into the colon. Its valvular function is purely a mechanical effect of the apposition of the ileocecal valve lips in response to increased intracolonic pressure and cecal distention, dependent only on anatomic factors, and is preserved even in the cadaver.[5, 12, 14]

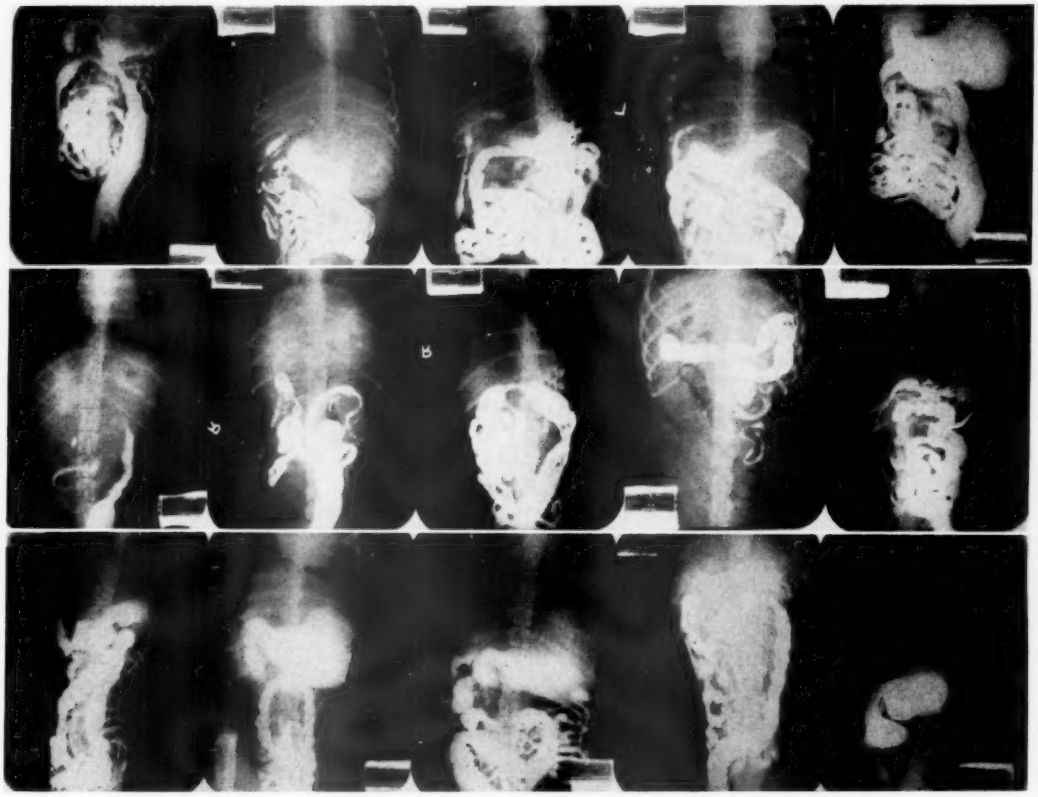

Fig. 4.—Roentgenograms obtained 8 hours after hypertonic barium meal in *A*, normal group, *B*, group with pylorectomy, and *C*, group with ileocecal interposition. There is absence of gastric opacification in animals with pylorectomy while early small bowel evacuation is noted both in those with pylorectomy and those with ileocecal interposition.

The ileocecal sphincter consists of a thickened circular layer of the terminal ileal muscle which alternately contracts and relaxes. Although the ileocecal sphincter transmits the peristaltic waves presented to it from the distal ileum, the pattern of sphincteric tone is dependent upon neurohumoral and local mechanical stimuli and thereby controls the rate of passage of chyme from the terminal ileum into the colon.[3, 4, 6, 9, 12, 13] While precise comparison of the physiologic mechanisms of function of the pylorus and ileocecal sphincter is not possible, the ileocecal sphincteric action can be characterized as similar to that which obtains in the normal pyloric control of gastric evacuation. From

the results of this study it is seen that after pylorectomy gastric emptying is delayed to normal or somewhat beyond normal rates in the presence of an interposed isoperistaltic ileocecal sphincter between the stomach and duodenum.

Certain other operative techniques for the establishment of gastrointestinal continuity after gastrectomy (that is, the construction of a deliberately small gastric outlet, the preservation of the pyloric sphincter, and the interposition of a segment of jejunum or colon between the gastric remnant and intestine) have been utilized to prevent rapid emptying of the gastric pouch.[1, 8, 10, 15]

Although it has been implied in this report that the delayed gastric emptying produced by ileocecal interposition is dependent upon the sphincter itself, this supposition has not been proved. Possibly the delayed evacuation is a result of the mechanical impedance offered by the interposed segment of intestine with a small lumen and would have resulted from similar interposition of a segment of either small bowel or colon. It seems more reasonable, however, that the sphincter itself is the basis for the observed alterations of gastric emptying. The feasibility or efficacy of clinical application of ileocecal interposition for the elimination or the prevention of excessively rapid gastric emptying as a consequence of operative ablation of the pylorus is uncertain.

The rapid appearance of colonic opacification in the presence of delayed gastric emptying in the animals with transposed ileocecal sphincters is best explained as being the result of rapid passage of small bowel chyme unimpeded (because of absence of the normal ileocecal regulatory apparatus) into the colon.

CONCLUSIONS

1. Canine gastric emptying of hypertonic glucose solution is abnormally rapid after pylorectomy even when the gastric capacity is normal.

2. The isoperistaltic interposition of the ileocecal sphincter between the stomach and duodenum after pylorectomy produces a normal or slightly prolonged gastric emptying time and there is apparently good nutritional maintenance in such animals.

3. There appears to be rapid passage of hypertonic glucose from the small bowel into the colon in an animal which has undergone gastroduodenal interposition of the ileocecal sphincter apparatus.

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THE BUCCOPHARYNGEAL PROPULSIVE MECHANISM IN HUMAN DEGLUTITION

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DEGLUTITION is an amazingly complex act about which much remains to be learned by further study with such methods as cinefluorography. One interesting aspect of deglutition is the contribution of oral and pharyngeal musculature to the transport of liquid ingesta. Falk,[4] Meltzer,[8] and Kronecker[7] showed the importance of the so-called squirt mechanism whereby, in the dog and in the human being, the mouthful of liquid is projected forcefully from the mouth to varying distances down the esophagus. This movement takes place at a rate faster than that of peristaltic conveyance, a fact recognized by Cannon.[3] The importance of buccopharyngeal pressure in the swallowing of liquids is acknowledged also by Inglefinger[5] in his comprehensive review of the subject.

Descriptions of the mechanism by which forceful conveyance from the mouth is achieved are found in the writings of Roberts,[10] Ardran,[1] Johnstone,[6] Ramsey and associates,[9] Saunders and colleagues,[12] and Rushmer and Hendron.[11] With few exceptions these cineradiographic studies were carried out on normal subjects. In these accounts, varying emphasis is placed on the role of the posterior tongue as the rapidly moving, forcefully thrusting piston which propels the ingesta toward the stomach.

Previous studies of surgically altered individuals at this institution[13, 14] indicated that the squirt mechanism is a significant factor in human deglutition, and that it plays a role in the deglutition of individuals whose lower propulsive mechanisms have been surgically disabled. Because of its demonstrated importance, it seemed worth while to study this phenomenon further in an attempt to confirm the views of previous workers regarding normal subjects and to extend the studies to include additional abnormal ones.

MATERIALS AND METHOD

Five of the films available on normal subjects were selected for further study with particular reference to the squirt mechanism. Eight abnormal subjects were studied. The nature of the aberrations from normal are stated in the individual case presentations and in Table I. The cineradiographic examinations were performed with a Phillips image intensifier and a 16 mm. Auricon camera. Pictures were taken at a speed of 24 frames per second. The films were studied on a Perceptoscope analyzing projector. Tracings of

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TABLE I. PATIENTS STUDIED

PATIENT	AGE	SEX	DIAGNOSIS	DISABILITY (DEGREE OF DYSPHAGIA)
A. W.	65	M	Paralysis, cranial nerves X and XII	Moderate
A. M.	63	F	Amyotrophic lateral sclerosis	Severe
J. Y.	46	M	Obstructing hypopharyngeal tumor	Severe
H. C.	74	M	Obstructing hypopharyngeal tumor	Severe
J. O'C.	44	M	Postoperative status (anterior oral resection)	Slight
M. deG.	53	F	Postoperative status (posterolateral oral resection)	Moderate
T. McM.	75	M	Postlaryngoglossectomy status with recurrent carcinoma	Moderately severe
W. S.	62	M	Intrinsic cancer, posterior tongue	Severe

individual frames were made for study purposes. The patients were filmed in the upright position after the imbibition of a 30 c.c. mouthful of a moderately thick barium suspension. Films were taken in both lateral and anteroposterior views, and some of the patients were studied during deglutition in the recumbent position to eliminate the effect of gravity. The role played by gravity in the transport of aliment through the hypopharynx is believed to be a minor one, depending upon the position of the subject and the consistency of the bolus.

After an earlier trial of 35 mm. film, the 16 mm. film was chosen because of greater economy and convenience, particularly in the availability of analyzing projection equipment. It was realized that there might be loss of some of the finer details of motion at 24 frames per second, but this was not of significant degree.

RESULTS

Studies of the Normal Subjects.—Analysis of the film sequences in the normal subjects confirmed in general the descriptions by previous authors of the buccopharyngeal stages of deglutition. Two features of the participation of the posterior tongue warrant emphasis, first, the sequence of separate phases which could be recognized, and second, the one phase of the lingual push-back which took place at a markedly accelerated speed.

Five separate phases were observed:

1. First, the tongue assumed a swallow-preparatory position with the mouthful blocked at the faucial level (Fig. 1, *A*). An elevation of the posterior dorsum of the tongue was in contact with the velum.

2. As the act of swallowing began, these separated, allowing the bolus to pass.

3. The posterior tongue then started a forward movement (Fig. 1, *B*), and it assumed the shape of a vertically steepening ramp.

4. After the bolus had started to flow down this ramp, there occurred a rapid, forceful posteriorward thrust of the posterior tongue toward the palatopharyngeal partition and posterior palatopharyngeal wall (Fig. 1, *C*). The speed of this movement was impressive. In addition to this piston thrust there occasionally occurred in some subjects a downward movement of the

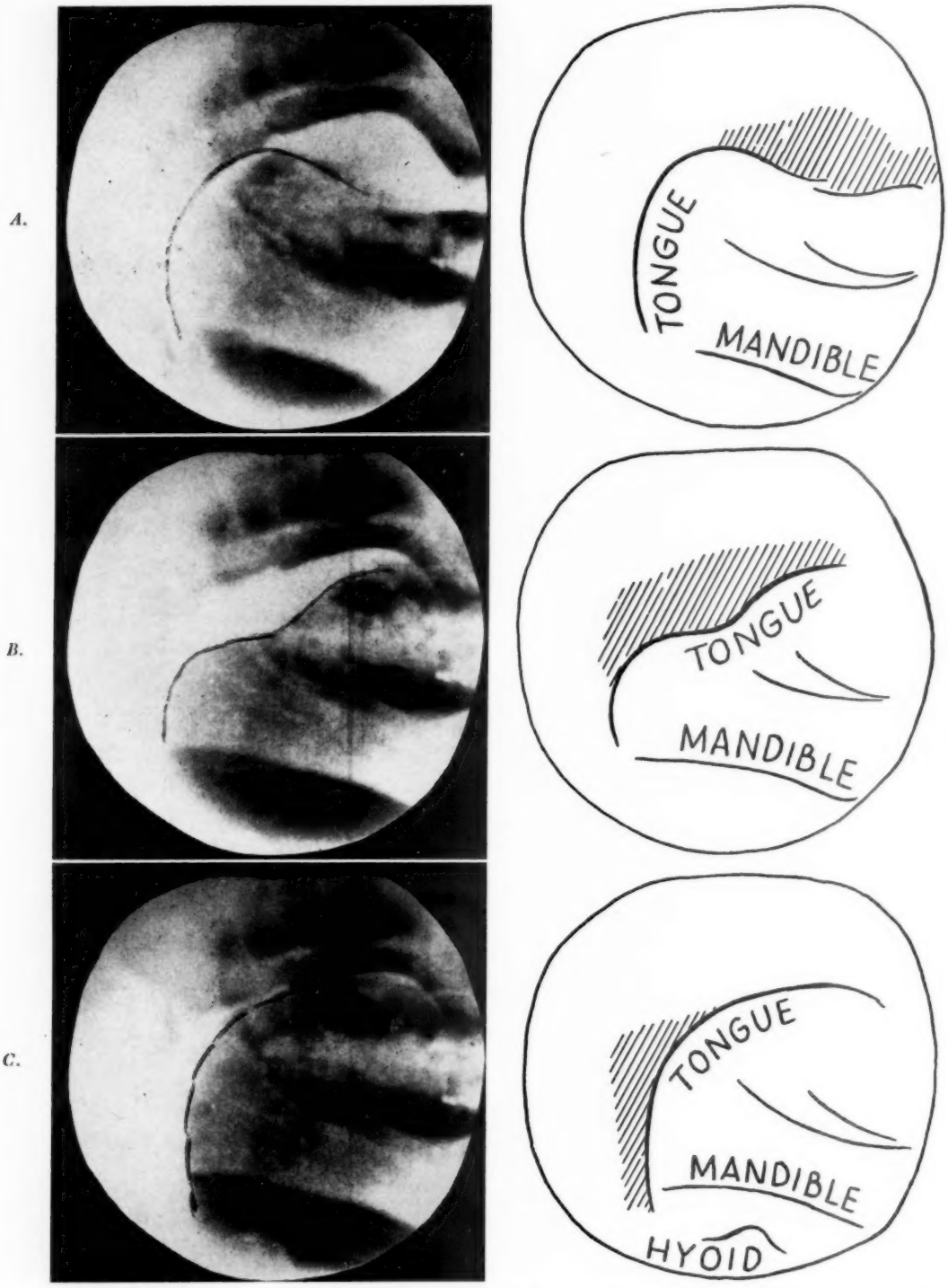

Fig. 1.—Lateral view of barium passing from mouth to pharynx in normal subject. Three frames from a single swallow, which show the movements of the posterior tongue in the buccopharyngeal squirt mechanism. Fig. 1, *B* is 13 frames after Fig. 1, *A*. Fig. 1, *C* is 6 frames after Fig. 1, *B*. The outline of the moving dorsum of the tongue has been demarcated in black on the radiographs.

entire organ and a rolling backward as well. Certain of these actions were seen in exaggerated form in the "trick drinker" mentioned by Ramsey and his group.[9] As the tail of the bolus passed, it was followed by a stripping wave of the pharyngeal constrictors and the lingual musculature.

5. The structures returned to resting position.

These analysis of films of normal swallow corroborated Bosma's view that the tongue is the principal mobile agent in the penetration of the bolus into the pharynx. This large muscular structure is capable of rapid and forceful movements over a wide range.

Studies of Abnormal Subjects.—

Patients with obstructing lesions in the hypopharynx: J. Y. had a recurrent sarcomatous tumor of the larynx obstructing the hypopharynx. He had extensive fibrosis of the tissues of the neck, probably related to heavy irradiation therapy, and severe dysphagia with a 60-pound loss of weight. Cineradiographs showed a vigorously active buccopharyngeal squirt mechanism propelling the barium past the site of hypopharyngeal obstruction. The major force of the propulsion appeared to be provided by the tongue, since the fibrotic palatopharyngeal walls participated very little.

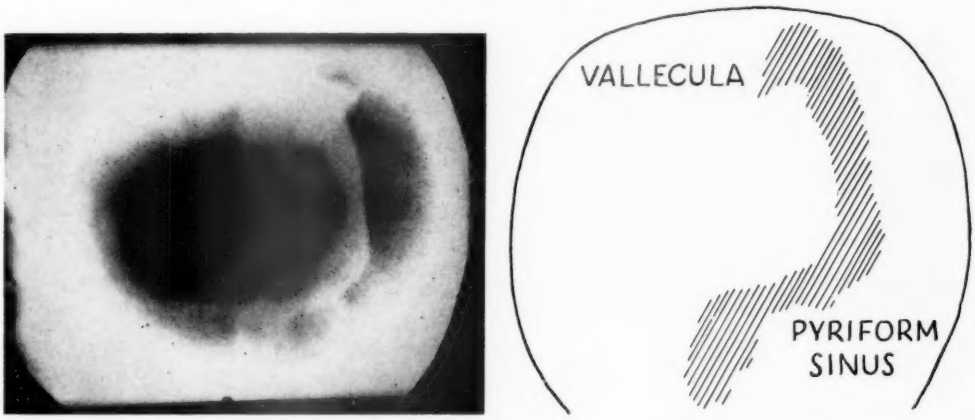

Fig. 2.—(H. C.) Anteroposterior view of barium descending through pharynx and esophagus, flowing entirely through the uninvolved side as it leaves the pyriform sinus to enter the esophagus.

H. C. had a large carcinoma filling the hypopharynx, arising from the left side, and producing an externally visible mass in the left side of the neck. Cineradiographic studies demonstrated the rapid propulsion of the ingested barium around the huge tumor with impetus derived from the buccopharyngeal squirt mechanism. Repeated swallowing efforts were noted, which drove the bolus stepwise through the area of obstruction (Fig. 2).

It was concluded from the study of these 2 patients that the piston thrust of the tongue is an important factor in the movement of ingesta past sites of obstruction in the upper food passages.

Patients with postoperative disability: J. O'C. had undergone a resection of the anterior floor of the mouth and anterior inferior lingual musculature,

as well as the mylohyoid. Cineradiographs showed an effective squirt mechanism in 1 swallow. After this, however, there was abnormal runoff of barium from the mouth, which flooded the hypopharynx. The evacuation of the flooded hypopharynx was achieved by a forceful backward thrust of the posterior tongue against the pharyngeal constrictors.

M. deG. had undergone a resection of the left hemimandible and floor of mouth in continuity with left radical neck dissection. The resultant dysphagia for solid foods was understandable after the cineradiograph had been viewed. It was seen that the surgical tethering of the tongue had interfered with completeness of the push-back mechanism, so that the squirt was incomplete and there was accumulation of residuum in the hypopharynx, which required several swallows for clearance.

The lessons from the study of these 2 patients are, first, that an additional function of the posterior tongue is that of important participation in clearance of sudden floodings of the hypopharynx and, second, that compensation for loss of a forceful push-back motion is attempted by means of rapid repetitive efforts.

Fig. 3.—(T. McM.) Lateral view of single frame from cinefluorograph. Implanted radon seeds are present. The failure of the tongue to carry out its usual push-back motion is seen.

Patient with surgical disability and recurrent tumor: T. McM. had undergone laryngectomy with partial resection of the posterior tongue for carcinoma in the vallecular region. A recurrence had developed in the posterior tongue. Cineradiographic study showed that there was loss of the squirt mechanism, which usually persists after laryngectomy. As a consequence, there was very slow and labored passage of bolus through the hypopharynx. The posterior tongue formed a satisfactory ramp for the decanting of the barium, but there was virtually no push-back motion, despite repeated efforts. Partial compensation for the impairment could be noted in that the posterior pillars could be seen drawing down against the relatively immobile tongue. This is an interesting example of the manner in which, in abnormal situations, exaggerations of normal mechanisms can be seen to good advantage. (Fig. 3).

This study indicated the importance of the piston thrust in normal transport, and showed how poorly a thick bolus travels by gravity alone.

Patient with intrinsic posterior lingual tumor: W. S. had a large cancer involving much of the posterior tongue. Resection was not considered feasible. Cinematographic x-ray study demonstrated marked impairment of the several components of the squirt mechanism, so that there was great slowing of passage of the bolus, despite repeated swallowing efforts. The posterior tongue and the posterior pharyngeal wall never quite fully approximated, and the hypopharynx was not completely evacuated (Fig. 4).

It was concluded that a space-occupying lesion in the posterior tongue can cause significant derangement of the squirt mechanism, a disability for which the pharyngeal constrictors are apparently unable fully to compensate.

Patients with neurologic alterations of lingual function: A. M. had amyotrophic lateral sclerosis. Her major disabilities were in speech and swallowing. In the cinefluorographic study it was seen that she was unable to place the bolus properly into the normal preparatory position. As a consequence, the first stage of swallow was never seen as a coordinated act, and no squirt motion occurred (Fig. 5).

When the bolus finally reached the hypopharynx, apparently largely by gravity, fairly normal propulsion was provided by pharyngeal constrictors.

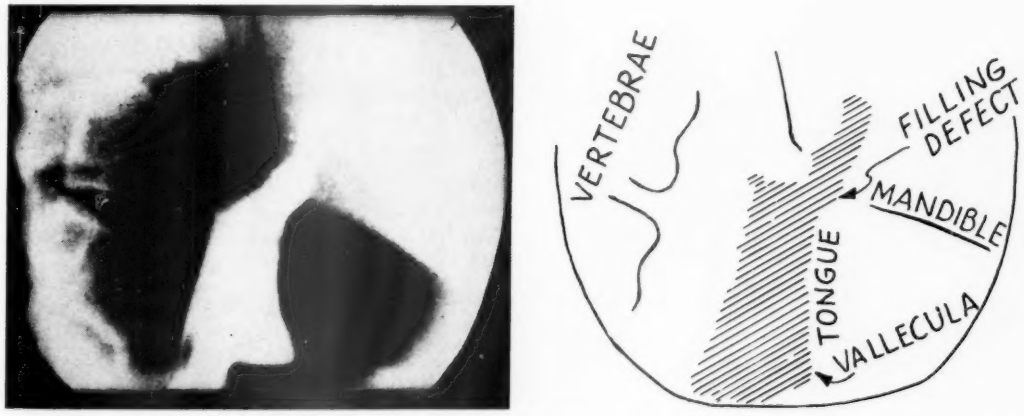

Fig. 4.—(W. S.) Lateral view of a single frame from cinefluorograph which shows a deformity, an indentation, in the posterior tongue at the site of a tumor. In this radiograph, which is a positive, the barium and other radio-opaque substances appear black.

It is concluded that, in some neurologic diseases, dysphagia can derive from motor impairment which results in failure to generate normal buccopharyngeal pressure.

A. W. had a carcinoma of the right lateral pharyngeal wall with high involvement of ipsilateral cervical nodes, which produced paralysis of the hypoglossal and vagus nerves, manifested by atrophy of the right half of the tongue and immobility of the right vocal cord. The cinematographic study of deglutition showed good oral and oropharyngeal transport of bolus, but some accumulation of residual barium in the hypopharynx. This was cleared after a few extra swallows, but some intrusion into the larynx occurred. The

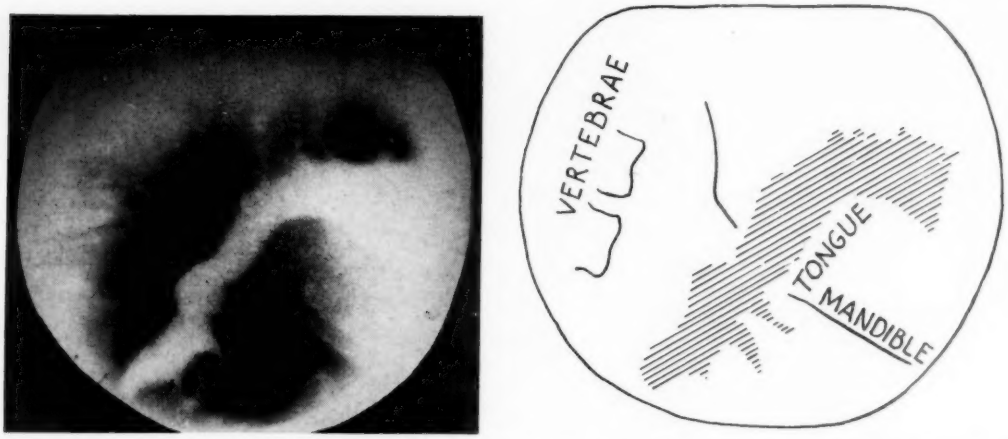

Fig. 5.—(A. M.) Lateral view of single frame from cinefluorograph which shows uncoordinated passage of barium from mouth to pharynx with no organized propulsive effort by the tongue.

finding of only moderate disability from unilateral vagal and hypoglossal paresis is of interest, for it indicated successful compensatory function of the nonparalyzed pharyngeal and lingual musculature.

DISCUSSION

Detailed analysis of cinematic radiographs of the buccopharyngeal stages of deglutition makes possible the recognition of separate phases of the participation of the posterior tongue in the squirt mechanism. This highly complex synergy of many muscles may be deranged at different phases by different pathologic states. In one patient (T. McM.), the lesion resulted in interference with the push-back movement only. In another (W. S.), the pathologic process had impaired the entire motor act. In a patient with a disturbance of innervation (A. M.), the swallow synergy was never effectively integrated. In another patient (A. W.) the moderate degree of disability from unilateral tenth and twelfth nerve paresis was seen. The importance of effective generation of buccopharyngeal pressure was demonstrated in 2 patients (J. Y. and H. C.) in whom such forces were able to propel ingesta past obstructing lesions. In a previous study[14] it was shown that this same pressure served to push the bolus through a noncontractile segment of pharyngoesophagus which was the site of a pedicle graft reconstruction. The major role of the posterior tongue is stressed in the pharyngeal phase of swallow. In addition to its role in normal deglutition, it provides a major contribution to clearance of the hypopharynx of unanticipated large accumulations of ingesta, as demonstrated in patient J. O'C.

SUMMARY

1. A group of subjects was studied by cinefluorographic analysis to gain further information concerning the dynamics of the buccopharyngeal phases of swallowing.

2. Five of the subjects were normal, and 8 were individuals with alterations in function based on neoplasm, neurologic disorder, or operation.

3. It is seen that there is a significant propulsive force generated in the mouth and/or pharynx which coincides with the squirt mechanism described by earlier authors.

4. The force results from a complex interaction of tongue and adjacent structures.

5. Several phases to the kinetic interplay can be recognized.

6. The manner in which various pathologic states can interfere with these phases is demonstrated.

7. The buccopharyngeal squirt mechanism can serve to propel ingesta past obstructing lesions in the hypopharynx.

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THE EFFECT OF SEROTONIN AND SEROTONIN PRECURSOR ON PANCREATIC SECRETION IN THE DOG

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SINCE the discovery in 1933 by Erspamer and associates[4] of an active amine present in large quantities in the mucosa of the gastrointestinal tract of animals, considerable experimentation has evolved concerning the physiologic role of this substance, later called serotonin (5-hydroxytryptamine). In 1954 Thorson and colleagues[10] first described a series of cases illustrating the syndrome now known to be produced by functioning carcinoid tumors releasing large quantities of serotonin into the blood. In addition, aberrations in serotonin metabolism have been related to a variety of malfunctions of the gastrointestinal tract.[6, 11]

Recently, the demonstration by Black and his group[1] of the inhibition of normal acid secretion by serotonin in dogs with gastric fistulas has focused considerable interest on serotonin as a possible regulatory substance on normal gastrointestinal activity and secretion.

At the present time little evidence exists, however, regarding the relationship of serotonin to pancreatic secretion. This report describes the effect of serotonin (5-HT) and serotonin precursor, 5-hydroxytryptophane (5-HTP), on the external pancreatic secretion in the dog.

METHODS

Successful chronic total pancreatic fistulas were prepared in 18 adult mongrel dogs by means of a modification of the techniques of pancreatic duct cannulation described by Elman and McCaughan[3] and by Routley and associates.[9]

Under intravenous pentobarbital sodium anesthesia (25 mg. per kilogram), the abdomen was entered through a midline incision and the duodenum with its mesentery containing the pancreas was delivered into the wound (Fig 1). The entrance of the common bile duct into the duodenum was identified and the surrounding pancreas avulsed from this region to insure interruption of the small, but significant, accessory pancreatic duct. The short main pancreatic duct was identified at its entrance into the duodenum approximately 3 cm. distal to the accessory duct. After incision of the serosa of the duodenal wall, the duct was carefully dissected free for a distance of 4 to 5 mm. into the duodenal wall and cannulated with a No. 200 polyethylene catheter containing a tightly fitting plastic collar. Two sutures were placed on either side of the

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collar to afford fixation of the catheter to the duodenum and the duct without compression. A large-bore, loosely fitting polyethylene tube was then passed as a sleeve over the catheter and both tubes were delivered through a right-flank stab wound. The outer sheath was employed to prevent troublesome kinking of the catheter and was firmly attached to the duodenum with silk sutures.

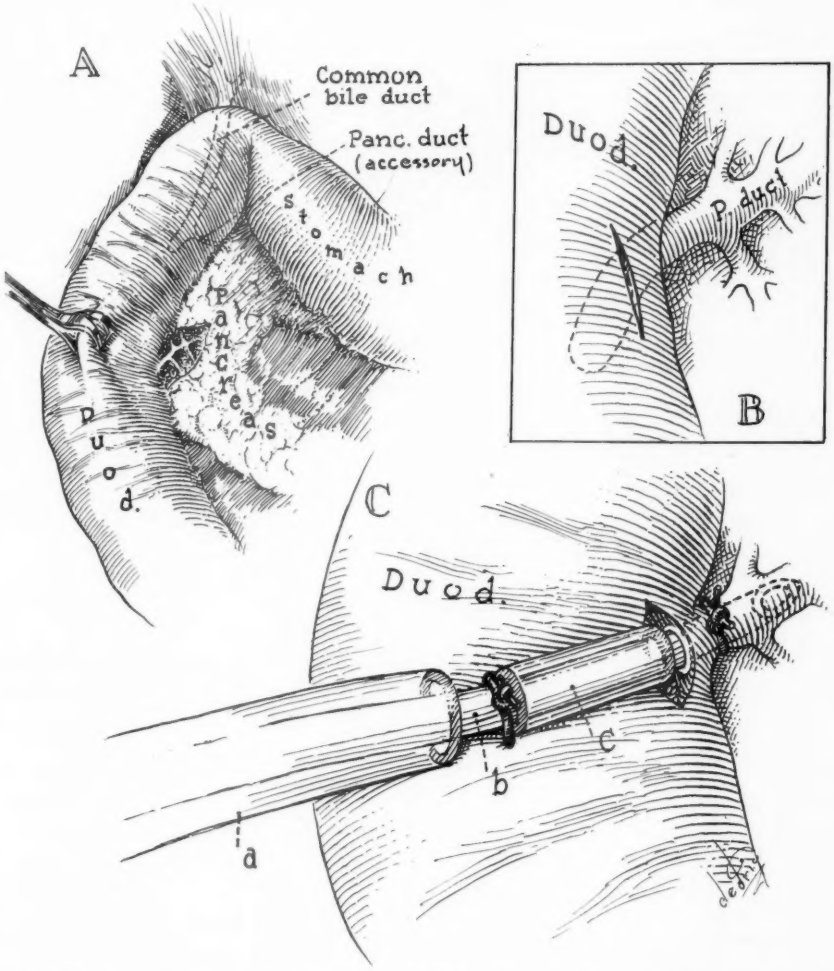

Fig. 1.—Method of pancreatic duct cannulation. The anatomy is shown in *A*. The small accessory pancreatic duct is avulsed posteriorly between the pancreas and its junction with the terminal common bile duct. The larger main pancreatic duct is identified anteriorly approximately 3 to 4 cm. below the level of the entrance of the bile duct into the duodenum. Incision of the duodenal serosa *(B)* is performed and the intramural portion of the pancreatic duct is dissected to obtained greater length. Care is taken not to incise the duodenal mucosa. *C* shows the cannulation of the pancreatic duct with a polyethylene catheter *(b)* which has a short, tightly fitting collar *(c)*. Ligatures are placed on either end of the collar, resulting in excellent fixation of the catheter to the duodenum and the pancreatic duct. A large loosely fitting sleeve *(a)* is placed over the smaller cannulating catheter to prevent kinking and both tubes are delivered through a right flank stab wound.

A Witzel gastrostomy was performed with another polyethylene catheter which was delivered through a left-flank stab wound. This tube was of a size sufficient to allow the pancreatic catheter to fit snugly within it when joined, thereby forming an external pancreatic gastric fistula.

In a few days after their recovery from the operative procedure, the animals were placed on a modified Pavlov sling and the catheters were separated

to allow collection of pancreatic juice. No anesthesia or sedation was utilized during any collection period.

In 52 experiments, after a steady flow rate of pancreatic juice had been established, the changes in rate of secretion, pH, bicarbonate content, and amylase activity were measured under the following experimental conditions: (1) 30-minute control collection periods in dogs fasted for 12 hours; in 8 experiments collection of pancreatic juice was also performed in dogs fed a mixture of horsemeat and 0.1N hydrochloric acid in order to obtain a food-stimulated control flow of pancreatic juice, (2) 30-minute collection periods following the single intravenous administration of serotonin creatinine sulfate (0.2 mg. per kilogram), (3) 15-minute collection periods after the single intravenous administration of secretin (Eli Lilly and Company, 1 U. per kilogram), (4) 15-minute collection periods after the single intravenous administration of serotonin and secretin through separate sites, and (5) 30-minute collection periods following the intravenous administration of 5-hydroxytryptophane (15 to 25 mg. per kilogram).

All pancreatic juice was collected on ice, and volume flows were related to 1-hour periods for comparison purposes. Bicarbonate concentration was determined immediately after the collection period by the Van Slyke method and reported as milliequivalents per liter of pancreatic juice. The Beckman pH meter was used to determine pH. Amylase activity was determined by the modified Somogyi method and reported as units.

RESULTS

Intubation of the pancreatic duct was well tolerated in all animals studied. Electrolyte problems were not encountered in the successful preparations and all dogs appeared to be in good clinical condition. Repeated experiments were performed until dislodgement or plugging of the catheters occurred. The average successful duration of pancreatic duct intubation was 7 days, while in a few animals intubation for as long as 3 weeks was possible.

Pancreatic Juice Flow.—Fig. 2 shows the results obtained in 3 typical experiments. Fig. 3 shows mean values in 26 parallel experiments.

1. Rate of flow of pancreatic juice in the fasting control dogs was 14 c.c. per hour with a range of 10 to 20 c.c. per hour. In food-stimulated controls, flow averaged 20 c.c. per hour.

2. After the intravenous administration of serotonin (5-HT), a marked reduction in flow rate occurred with an average reduction to one-third of the rate in the fasting normal controls. Maximal depression of flow was present within 15 minutes and usually lasted for 1 hour. Signs of systemic serotonin activity were noted in all dogs as evidenced by diarrhea, micturition, excessive salivation, and restlessness. With dosages of serotonin less than 0.2 mg. per kilogram, fewer side effects were exhibited but depression of pancreatic juice flow still occurred. Depression also occurred in food-stimulated pancreatic juice flow with results similar to those in the fasting control experiments.

A few experiments were performed with a constant intravenous infusion of serotonin at a rate of 20 mcg. per kilogram per minute for 2 hours. Diminished pancreatic juice flow was present during the entire period of infusion. Systemic signs of serotonin activity were noted only during the latter part of the infusion period.

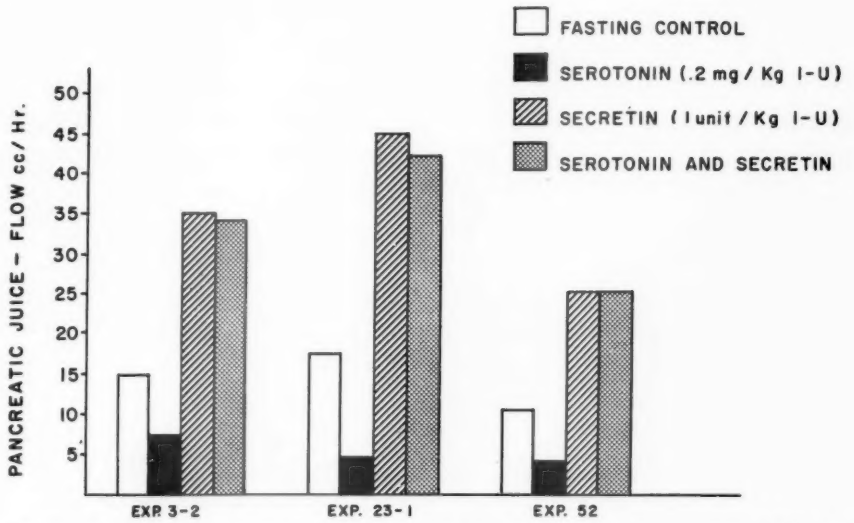

Fig. 2.—Effect of serotonin on pancreatic juice flow. Sequential pancreatic juice flow rates are shown from 3 typical experiments in different dogs.

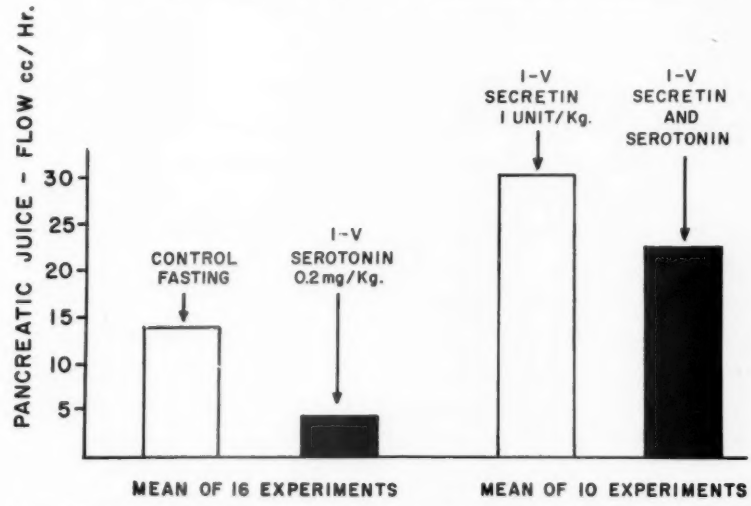

Fig. 3.—Effect of serotonin and secretin on pancreatic juice flow. Serotonin produces a significant mean fall to 30 per cent of the control fasting mean flow ($p < 0.001$). Secretin produces a marked rise in pancreatic juice flow which is not significantly altered after the administration of serotonin ($p > 0.05$).

3. Following the intravenous administration of secretin, rates of flow promptly doubled to an average of 30 c.c. per hour. Secretin response occurred immediately. Maximum flow rates were reached within 10 minutes, with a rapid return to normal after 30 minutes.

4. Serotonin did not affect appreciably the secretin-stimulated pancreatic juice flow. When secretin was administered during the period of maximum

depression of flow by serotonin, a prompt rise in flow rate occurred which approached the usual secretin-stimulated levels. Increases in flow rate due to secretin occurred despite marked systemic serotonin reaction.

5. Following the intravenous administration of 5-hydroxytryptophane (5-HTP) a depression of pancreatic juice flow occurred which was similar to that following serotonin administration, but was neither as prompt nor as marked (Fig. 4). Maximum depression of flow did not occur until 1 hour after administration of 5-HTP with an average depression to 50 per cent of the rate in the control fasting period. Secretin-stimulated pancreatic juice flow, however, was not affected by 5-HTP. Typical signs of systemic effects were also noted and were identical to those produced by serotonin.

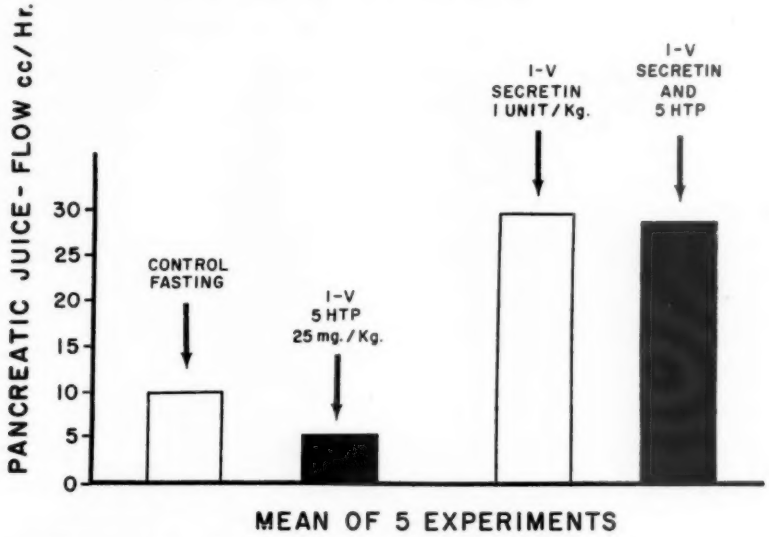

Fig. 4.—Effect of 5-hydroxytryptophane (5-HTP) and secretin on pancreatic juice flow. A fall to 50 per cent of the control fasting mean flow is produced by 5-HTP. ($p < 0.05$). Secretin-stimulated pancreatic juice flow is not affected by 5-HTP.

BIOCHEMICAL STUDIES

Amylase concentration following administration of either 5-HT or 5-HTP was variable. In some experiments a rise in amylase concentration occurred, while in others a drop or no change in concentration was noted. Similar variable results were encountered in the study of pH of pancreatic juice. No trends were demonstrable in the study of these two parameters.

Bicarbonate concentration of pancreatic juice after the administration of serotonin showed a consistent and significant drop in all animals when compared to that of the fasting control period. A marked rise in bicarbonate concentration compared to fasting control levels occurred following the administration of secretin. Serotonin did not alter the bicarbonate response to secretin. Alterations in bicarbonate content in this group of experiments are shown in Table I.

Results following 5-HTP administration were similar. It was evident, therefore, that bicarbonate concentration varied consistently and directly with the rate of flow of pancreatic juice.

TABLE I. CHANGE IN BICARBONATE CONCENTRATION IN PANCREATIC JUICE

EXPERIMENT NO.	PANCREATIC JUICE BICARBONATE CONCENTRATION (MEQ./L.)			
	CONTROL FASTING	SEROTONIN (0.2 MG./KG. I-V)	SECRETIN (1 U./KG. I-V)	SEROTONIN AND SECRETIN
3-1	46	29	116	113
3-2	70	51	97	96
20	102	33	121	101
23-1	84	70	112	93
23	122	64	125	115
52	59	52	102	105
8	59	13	—	—
8-1	74	39	—	—
8-2	116	93	—	—

DISCUSSION

No adequate studies of the effects of serotonin or 5-hydroxytryptophane on external pancreatic secretion have been reported up to the present time in man or experimental animals. Warner, Janowitz, and Dreiling,[12] in a study of the duodenal aspirate in 10 patients, found no changes attributable to pancreatic juice flow after the intravenous administration of serotonin. This evidence appears contradictory to our finding of a prompt and marked depression in either fasting or food-stimulated pancreatic juice secretion by serotonin and by 5-hydroxytryptophane in dogs.

The mechanism of depression of pancreatic juice secretion by serotonin is not clear. It might be postulated that this is simply a reflection of the cardiovascular responses known to occur after serotonin administration which result in altered visceral hemodynamics. The potent stimulating effect of secretin in the presence of serotonin depression appears to negate this hypothesis.

It is further apparent that serotonin does not depress the pancreatic secretory cells directly because the prompt and rapid response to secretin is not inhibited.

Convincing evidence exists, however, that the action of serotonin on gastrointestinal secretion is mediated at some point in the parasympathetic or vagal pathway. White and associates[14] found that serotonin causes a drop in food-stimulated acid secretion in innervated Pavlov pouches in dogs. Changes in total acid were attributed partly to a decrease in hydrochloric acid and partly to increased mucin production. They concluded that since changes in acid and volume occur in Pavlov pouches and only questionably in Heidenhain pouches with vagal denervation, these effects must depend on the integrity of parasympathetic innervation. Furthermore, serotonin appeared to have no effect on the gastric secretory response to histamine.

Studies by Hendrix and colleagues[7] and Haverback and Davidson[6] have shown that serotonin has a stimulating effect on human intestinal motility. Both groups concluded that the motility response is mediated through cholinergic nerves distal to the ganglia.

An alternative mechanism for the action of serotonin on pancreatic secretion would be the inhibition of endogenous secretin formation or release from the duodenum. Because the pancreas is extremely susceptible to secretin stimulation, a fall in circulating basal levels of secretin would result in a profound drop in

rate of secretion of pancreatic juice. During this period, the pancreas would still be able to respond to the administration of exogenous secretin with a prompt increase in flow. Further studies attempting to define more clearly the mechanism of action of serotonin seem to be indicated.

Since most of the serotonin in the body exists bound in the mucosa of the gastrointestinal tract[5] and to a lesser extent in the platelets,[15] it is difficult to assess its physiologic role because no measurable amount normally exists free in the plasma. It is possible, however, that under certain circumstances release of tissue-bound serotonin may occur. Bulbring and Lin[2] have shown that local release of serotonin in the intestine may be important in the maintenance of normal peristaltic activity in human beings. White and Magee[13] have theorized that serotonin might play an inhibitory role in protecting the stomach and duodenum from peptic ulceration by stimulation of gastric mucin formation. Our finding of diminished flow of pancreatic juice with its alkaline and buffering qualities, following serotonin administration, tends to detract from the latter theory.

Increased intestinal activity due to serotonin has been described in several other conditions. Some of the diarrheal states have been studied to determine what role, if any, is played by serotonin. Increased amounts of urinary serotonin metabolites (5-hydroxyindole acetic acid) were found during exacerbations of nontropical sprue and of Whipple's disease in patients.[8] Decreased pancreatic function due to high blood levels of free serotonin is consistent with these findings and this fact may help clarify the pathophysiology involved. The theory that a combination of hyperperistalsis and poor absorption exists secondary to diminished pancreatic function is an attractive one for the explanation of part of the syndromes.

SUMMARY AND CONCLUSIONS

1. Chronic total pancreatic fistulas were established in dogs and pancreatic secretion was measured.

2. Serotonin administered intravenously produced a prompt fall in pancreatic juice flow which approached one-third of the fasting control flows.

3. Pancreatic juice flow stimulated by food was similarly depressed by serotonin.

4. Serotonin precursor (5-hydroxytryptophane) administered intravenously depressed pancreatic juice flow but the response was slower and less pronounced than that produced by serotonin.

5. Secretin-stimulated pancreatic juice flow was not affected by serotonin or serotonin precursor.

6. Secretin administered during the period of marked depression of pancreatic juice flow by serotonin or serotonin precursor produced a prompt rise comparable to that in secretin-stimulated controls.

7. Serotonin and serotonin precursor produced a fall in pancreatic juice bicarbonate levels, paralleling the rate of flow. No consistent change was measured in pH or amylase activity of pancreatic juice.

8. The possible mechanisms involving the action of serotonin on pancreatic secretion were discussed.

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CARCINOMA OF THE BREAST FOLLOWED BY PREGNANCY

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IT HAS been estimated that nearly 10 per cent of all cancers of the breast develop in women during their childbearing years. The expected incidence of pregnancy in such women is approximately 1 in 3. White[10] has shown in his collected series of 45,881 cases of breast cancer that there were 1,296 patients who had pregnancies either associated with the carcinoma or developing after initial treatment (Table I). This is an incidence of 2.8 per cent. Included in the 1,296 were 243 patients whose pregnancies developed after the initial treatment, an incidence of 0.52 per cent. In other words, 1 in 35 patients with carcinoma of the breast will have pregnancy as a complication, but if the cancer is found during the childbearing years, the figure is 1 in 3. One patient in 19 of childbearing age will become pregnant after mastectomy.

TABLE I. CASES OF PREGNANCY OR NURSING FOUND IN SERIES OF BREAST CANCER PATIENTS

COLLECTED SERIES	CASES	COINCIDENT CARCINOMA AND PERGNANCY OR NURSING	PREGNANCY OCCURRING AFTER TREATMENT	TOTAL
1850-1953	42,627	732	232	1,236
New York City				
Roosevelt Hospital	987	5	6	11
University Hospital	190	2	1	3
Bellevue Hospital	127	5	3	8
Seattle				
The Doctors Hospital	257	4	--	4
Providence Hospital	347	5	1	6
Tumor Institute	403	12	--	12
Swedish Hospital	943	16	--	16
Totals	45,881	783	243	1,296

Reprinted from White: Surg. Gynec. & Obst. 100: 662, 1955.

White has also shown that the incidence of carcinoma of the breast among patients who are pregnant is approximately 3 in every 10,000. He collected 238,299 cases of pregnancy, among which were found 74 cases of carcinoma (Table II).

It is generally accepted that there is a definite connection between hormone status and carcinoma of the breast in 40 to 50 per cent of the cases. This conclusion was drawn because of the improvement noted in patients who had developed metastasis from carcinoma of the breast and who were treated with either hormone obliteration or by the administration of either male or female hormones. There are at least 4 types of hormones that affect the breast in the human being. The most potent apparently are estrogens. Smith and

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TABLE II. INCIDENCE OF BREAST CARCINOMA AMONG PREGNANT WOMEN

	PREGNANCIES	BREAST CARCINOMAS
Bellevue Hospital, New York, Jan. 1, 1933, to May 31, 1950	37,790	7
Geneva, Switzerland, 1907 to 1939	41,094	2
Elizabeth Steele Magee Hospital, Pittsburgh, Pennsylvania	45,000	4
Presbyterian Hospital, New York	37,740	36
The Doctors Hospital, Seattle, October, 1945, to July, 1954	16,855	4
Providence Hospital, Seattle, 1944 to 1953	23,372	5
Swedish Hospital, Seattle, 1938 to 1953	36,448	16
Totals	238,299	74

Reprinted from White: Surg. Gynec. & Obst. 100: 662, 1955.

TABLE III. LEVELS OF ESTROGENIC COMPOUNDS IN SERUM DURING PREGNANCY

PERIOD OF PREGNANCY (MO.)	RAT UNITS PER LITER
0-3	10
4	10-130
5	50-220
6	150-500
7	200-500
8	300-900

Reprinted from Smith and Smith: Am. J. Obst. & Gynec. 33: 365, 1937.

Smith[7] have shown that the estrogen compounds found in the serum during pregnancy increase with the progress of the pregnancy until just before parturition (Table III).

I first became interested in the subject of pregnancy in patients with carcinoma of the breast in 1949 when I saw a young woman previously treated for carcinoma of the breast who was approximately 2 months pregnant. Several authorities whom I contacted gave no specific opinions concerning such cases and a review of the standard textbooks and available literature was equally unhelpful. The first patient and the 2 patients subsequently seen with the same problem were aborted after considerable discussion. The women died within a rather short time, which led me to conclude that the development of pregnancy after treatment for carcinoma of the breast was an undesirable complication. These cases initiated my interest in the problem, and through the intervening years I have accumulated 20 cases in the Los Angeles area. The patients all have either died or lived at least 5 years. This paper is a summary of the study of these 20 cases.

Twenty cases do not provide an adequate basis for conclusions, but such cases are not common. Harrington[2] had only 59 to report from 5,026 cases of carcinoma of the breast at the Mayo Clinic. Westberg[8] found 47 in 4,747 cases of breast carcinoma and Meltzer[5] found 42 in 5,000. My small series of 20 cases is apparently the fourth largest series in the world literature.

Three of the 20 patients were Negro and the rest were classified as Caucasian. The oldest patient was 40 years of age and the youngest was 19. The average age was 30. Table IV shows the ages by decades.

TABLE IV. AGES BY DECADES

DECADE	NO. CASES
10 to 19	1
20 to 29	10
30 to 39	8
40 to 49	1

The primary tumor was found in the right and left breasts in an equal number of instances. One patient developed another tumor in the opposite breast after 8 years which required a radical mastectomy. The shortest duration of symptoms prior to diagnosis was 2 weeks and the longest was 14 months. The average duration of symptoms was slightly over 3 months.

Pathology.—All 20 patients had adenocarcinomas, but there was an unusually high incidence of low-grade malignancies (50 per cent less than grade 4) in comparison to the average series. Table V shows that 80 per cent of the

TABLE V

	NO. PATIENTS				
	GRADE 1	GRADE 2	GRADE 3	GRADE 4	TOTAL
Stage I	2	4	4	6	16 (80%)
Stage II	0	0	0	4	4 (20%)
Total	2	4	4	10	20 (100%)

patients showed no evidence of node metastasis and their cancer was classified as stage I. This percentage is in contrast to the average series in which approximately 50 per cent of the patients only were found to be free of actual node metastasis at the time of treatment.

Treatment of these 20 patients varied slightly. Ten of the patients had a radical mastectomy only for treatment of the initial disease. Six patients had a radical mastectomy followed by postoperative radiation therapy. One patient had a radical mastectomy with preoperative radiation therapy. One patient, because the lesion was small and classified as grade 1 adenocarcinoma without evidence of node invasion, was treated by simple mastectomy only. However, she eventually died of her disease. Two patients were treated with biopsy by local excision, interstitial radium, and radiation therapy. Of the total 20 patients, 17 had a radical mastectomy with or without x-ray therapy, 1 underwent a simple mastectomy, and 2 were treated primarily with radiation techniques. One patient had bilateral radical mastectomies.

Analysis of Pregnancies.—The 20 patients had a total of 30 pregnancies. Thirteen full-term babies were born and 17 abortions occurred. Nine of the patients were delivered of 13 full-term babies, one of which was anencephalic. Three of the 9 mothers later died of their disease. Fourteen of the patients had 17 abortions. Seven eventually died of their disease. Five of the 14 had 6 spontaneous abortions and 2 died. Ten of the patients had 11 induced abortions and 6 died eventually of carcinoma. A comparison of the group that is living and well with the group that died shows that 11 living patients had a total

of 17 pregnancies. Seven of these ended in abortion and 10 went to term. The 9 patients who died had 13 pregnancies, 10 of which ended in abortion and 3 of which went to term. One full-term baby was anencephalic. In the group of 20 patients, 11 who are living and well have lived an average of 13 years since their original disease was treated. The 9 who died of their disease lived an average of 6 years and they lived an average of 22 months after the metastasis had been discovered. The shortest period of survival was 1 month and the longest was 4 years and 8 months.

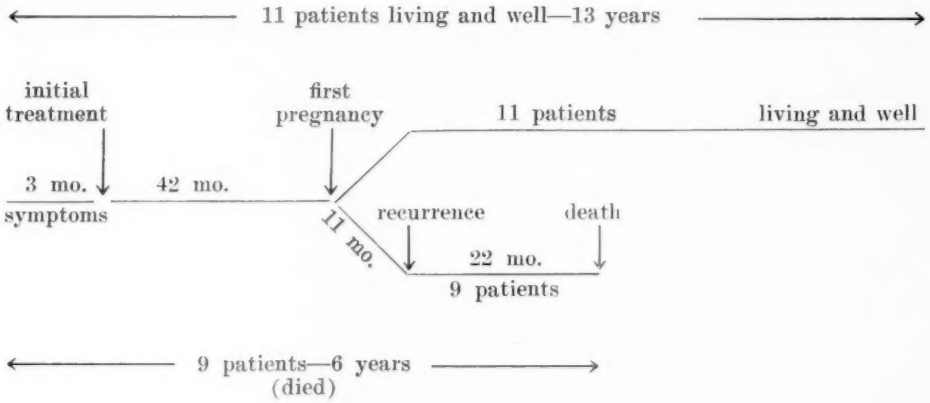

Fig. 1.

I would like to be able to compare the duration of life after metastasis in the group of women who became pregnant with the duration of life in a group of patients who did not become pregnant in order to determine whether or not the pregnancy has affected the survival time after metastasis. Unfortunately, it is difficult to do this. My own series of 20 cases with 9 deaths is too small to be significant. Comparisons would, therefore, mean nothing. Those who have studied the problem of pregnancy after mastectomy have not recorded their figures for duration of life after recurrence. Therefore, I cannot make the series large enough to be significant. Table VI gives the survival times by stages in the 9 women who died in this series.

TABLE VI. POSTRECURRENCE TIME TO DEATH

	CASES	MONTHS
Stage I	6	23
Stage II	3	18
Total	9	22

Lee and Tannenbaum[4] recorded 363 cases of patients treated with radiation whose average life after metastasis was 25 months. Geschickter[1] reported 585 patients in his textbook who survived an average of 18 months after local recurrences had been found. Shimkin and colleagues[6] have done the best statistical study of the problem in their report of 1056 deaths from breast carcinoma. They showed that the most significant factor in survival was the site of the metastasis, and that the stage at operation was less important.

Patients with local recurrences survived 28 months. Those with osseous metastasis survived 24 months, and those with generalized metastasis survived only 10 months. With stage I the mean survival was 19 months and with stages II and III it was 13 months. Table VII summarizes these reports.

TABLE VII. SURVIVAL AFTER METASTASIS IN MONTHS

AUTHOR	NO. CASES	TYPE OF TREATMENT	SITE OF RECURRENCE	METASTASIS TO DEATH (MO.)
Lee and Tannenbaum	365	Radiation	?	25
Geschickter	585	Operation and radiation	Local	18
Shimkin	1,056	Operation and radiation	Local	28
			Osseous	24
			Generalized	10
			Stage I	19
			Stage II	13
			Stage III	13

Summarized from Shimkin et al.: Cancer 7: 29, 1954.

Survival Rates.—Table VIII shows the gross survival rates in the group of 20 cases.

TABLE VIII. GROSS NUMBER OF SURVIVORS

NO. CASES	5 YR. (%)	10 YR. (%)	15 YR. (%)
15	75	--	--
10	--	50	--
3	--	--	15

Table IX shows the survival rates by stages.

TABLE IX. SURVIVORS BY STAGE

NO. CASES	STAGE	5 YR. (%)	10 YR. (%)	15 YR. (%)
16	I	65	45	15
4	II	10	5	--

Table X shows the survival rate by microscopic grading.

TABLE X. SURVIVORS BY GRADE

NO. CASES	GRADE	5 YR. (%)	10 YR. (%)	15 YR. (%)
2	1	50	50	50
4	2	100	100 (all living)	25
4	3	50	25	--
10	4	80	40 (4 living)	10

White[10] has reviewed the world literature in 7 different languages from 1850 to 1953 and has compiled 5- and 10-year results to which he added his own cases. Table XI compares my series of 20 cases with White's summary of the world literature up to 1953.

TABLE XI. SURVIVAL RATES

	WITHOUT METASTASIS				WITH METASTASIS				TOTAL			
	NO. CASES	5 YR.	10 YR.	15 YR.	NO. CASES	5 YR.	10 YR.	15 YR.	NO. CASES	5 YR.	10 YR.	15 YR.
1850-1953	194	124 (64.6%)	98 (51%)	—	74	32 (43.8%)	26 (34.6%)	—	268	157 (59%)	125 (47%)	—
Author	16	13 (81.2%)	9 (56.2%)	3 (18.7%)	4	2 (50%)	1 (14 yr.) (25%)		20	15 (75%)	10 (50%)	3 (15%)

DISCUSSION

When a patient who has had a cancer of the breast becomes pregnant, her physician is confronted with a major decision to make concerning both the mother and the pregnancy. Will carrying the present baby to term affect her survival? Unfortunately, I cannot answer this question from my study of 20 cases. If the mother still has cancer cells in her body, whatever is done to the pregnancy will not affect her eventual outcome. Whether or not interruption of the pregnancy will give her an added span of life is a question I wish I could answer. Theoretically, it would help her and allow her to live a little longer in about 40 to 50 per cent of the cases, but this cannot be proved from this study or from available information from the literature. If the mother already has small children at home who need her, every month of additional useful life is worth something to these children and to the father. Dr. Kilgore[3] of San Francisco, in discussing this problem, has stated, "The child who loses his mother loses his most priceless birthright. I would by no means venture to suggest an answer to the question as to what bearing this fact should have upon our decision, complicated as it is by ethical, emotional, and frequently religious aspects; but nevertheless, it is a fact and it deserves consideration. A woman who is found to have axillary metastasis and who later becomes pregnant is highly likely to leave her child for someone else to raise."

From the available evidence I conclude that any woman who has had cancer of the breast should be advised against becoming pregnant for at least 4 or 5 years after the mastectomy. If her original disease was stage II, if she is in the early months of pregnancy, and if she has small children who need her, I will advise her to have a therapeutic abortion, especially if less than 4 or 5 years have gone by since her original treatment. If, however, the cancer was stage I, or if she has no children and greatly desires to have one, I would allow the pregnancy to go to term. The pregnancy will in no way affect the ultimate outcome as far as the patient is concerned, but it may hasten the time when she will have to leave her family for someone else to care for. I realize not all will agree.

SUMMARY

The cases of 20 women who have been treated for cancer of the breast and who subsequently developed 30 pregnancies are studied and reported. Admittedly, this is a highly select group. In 80 per cent the cancer was stage I when first treated, and in 50 per cent it was less than grade 4 microscopically.

Eleven of the women are still living and well. The shortest survival is 9 years, 2 months, as of Dec. 1, 1959. The longest survival is 15 years, 8 months. Neither interrupting the pregnancy nor allowing it to go to term has affected the ultimate outcome of any patient who has had cancer of the breast. Whether interruption of the pregnancy adds to the patient's lifetime cannot be determined from this study or from the available information of the world literature. Under certain circumstances and upon theoretical grounds, I would recommend therapeutic abortion if it is acceptable to the patient.

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ANGIOSARCOMA OF THE BREAST

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MOST recent reports concerning angiosarcoma related to operations on the breast have discussed the problem of postmastectomy lymphangiosarcoma that occurs in the lymphedematous extremity (the Stewart-Treves syndrome).[7] Equally as challenging, however, is the rare primary angiosarcoma of the breast. Its prognosis has been almost uniformly unfavorable, regardless of the type of treatment that has been employed. We found only 20 well-documented cases cited in the literature (Table I).

Primary malignant mammary tumors of blood vessel origin have been reported as angiosarcoma,[1, 4, 10, 11] angioblastoma,[5] metastasizing angioma,[2, 6, 19] hemangiosarcoma,[9] malignant hemangioendothelioma,[8, 16, 17] hemangioblastoma,[13] and hemangioendotheliosarcoma.[12] Stewart[16] estimated that in his experience 1 case of primary angiosarcoma of the breast was seen in every 2,000 carcinomas of that organ. Botham and co-workers[3] reviewed 50 years (1907 through 1956) of the Mayo Clinic experience with primary sarcoma of the breast and found only 34 cases. In none of these was the tumor considered to be angiosarcoma. However, Soule and co-workers[15] found that angiomatous tumors composed 13 per cent of a series of 500 consecutive primary tumors of the soft tissues of the extremities and that 5 per cent of the 500 were considered to be malignant. Stout[18] mentioned that 5 of the 34 malignant hemangioendotheliomas that he had collected were in the breast. This was the most frequent anatomic site in his series.

Our study was initiated as a result of our encountering at operation a patient with angiosarcoma limited to the breast and another patient with a metastatic tumor derived from angiosarcoma that was primary in the breast.

CASE REPORT

CASE 1.—A 47-year-old white woman, referred to the Mayo Clinic for treatment of metastatic angiosarcoma, had first noticed a tender swelling in her left breast in March, 1954. After biopsy, radical mastectomy was carried out in July, 1954, elsewhere. The pathologic diagnosis was angiosarcoma. An excisional biopsy of a recurrent mass involving the left axilla, also performed elsewhere in August, 1954, had revealed angiosarcoma involving fibroadipose and mammary tissue (Fig. 1).

On physical examination when she was seen here in July, 1957, the patient had no evidence of recurrent tumor in the left radical mastectomy scar or axilla. Laboratory examinations, including hemoglobin determination, leukocyte count, urinalysis, determination

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TABLE I. REPORTED CASES OF ANGIOSARCOMA OF THE BREAST (ALL CASES IN WOMEN)

AUTHOR (YEAR)	AGE (YEARS)	CLINICAL FEATURES	DIAGNOSIS	TREATMENT	COMMENT
Bormann (1907)	26	—	Right metastatic hemangioma	Operation for primary and repeated recurrences	Died after 21 months with metastasis to lung
Ewing (1928)	?	—	Metastatic angioma	Not specified	Died with metastasis to axilla, lungs, pharynx
Robinson and Castleman (1936)	18	Enlarged right breast, pain, discoloration	Right benign metastatic hemangioma	Simple mastectomy	Died after 36 months with metastasis to left breast, chest wall, mediastinum
Miller and MacCarty (1939)	38	Irregular mass, left breast; 16 months later, recurrent reddish-blue nodule of left breast, and mass in right breast	Original diagnosis: benign hemangioma; later: hemangioendotheliosarcoma	Right radical mastectomy; 5 operations for recurrences	Died with metastasis to lung
Hill and Stout (1942)	19	Bluish lumps, right breast	Original diagnosis: benign hemangioma; later: hemangioendothelioma	Right radical mastectomy	Died after 17 months with symptoms of abdominal hemorrhage
	65	5 cm. nodule of right breast, reddish-purple skin discoloration	Hemangioendothelioma	Radical mastectomy	Died after 2 months with metastasis to lung, skin
Stout (1943)	68	Lump, right breast; bluish skin discoloration after recent trauma	Hemangioendothelioma	Simple mastectomy	Died after 4 months with metastasis to lung, bone, skin
Enticknap (1946)	20	Lump, left breast, in first trimester of first pregnancy; large rounded 12 cm. mass, skin ulceration	Original diagnosis: inflammatory condition; later: angioblastoma	X-ray and simple mastectomy	Died after 6 months with metastasis to lung, skin
Mallory and coworkers (1949)	20	History of mass, left breast, 6 weeks	Original diagnosis: benign lesion; later: hemangiosarcoma	Radical mastectomy	Later: had lesions of left chest wall diagnosed malignant
Tibbs (1953)	39	Lump, right breast in pregnancy; 4 cm. swelling, reddish skin discoloration	Metastatic hemangioma	Simple mastectomy	Died after 10 months with metastasis to liver, spleen, kidney, ovaries, brain, spinal cord, skin
McClanahan and Hogg* (1954)	22	4 months' history, swelling of right breast after trauma	First biopsy: benign; later: angiosarcoma	Radical mastectomy	Died after 8 months with metastasis to lung, skin

Hogg* (1954)		Right breast after trauma			
	18	Orange-sized mass, left breast, after trauma	Angiosarcoma	Local excision	Died after 42 months with metastasis to cerebrum, lung, ovary, mesentery
	26	Mass, left breast	First biopsy: benign; later: angiosarcoma	Simple mastectomy	Died after 14 months with metastasis to liver, ovary
	23	Painful enlarged right breast with bluish skin discoloration in pregnancy	Angiosarcoma	Simple mastectomy	Died after 66 months with intraperitoneal hemorrhage; metastasis to left ovary, brain, lung, spleen
	28	4 months' history, pain in left breast; enlarged ecchymotic left breast developed	Angiosarcoma	X-ray, radical mastectomy	Died after 12 months with hemoptysis, metastasis to lung
	23	Painful mass, left breast, bluish discoloration, 10 days	Angiosarcoma	Radical mastectomy	Died after 16 months with metastasis to lung, bone
Edwards and Strouth (1956)	33	Tender mass, right breast, treated as inflammatory condition	Original diagnosis: benign lesion; later: angiosarcoma	Radical mastectomy	Died after 16 months with metastasis to lung, ovary; moderate hemoptysis
Patrick and coworkers (1957)	30	Pain and swelling, right breast, bluish skin discoloration for 7 weeks after trauma	Hemangioblastoma	Simple mastectomy, x-ray	Died after 20 months from hemoptysis with metastasis to lungs, liver, ovaries, ileum, bone
	23	Painless 3 cm. swelling, right breast, bluish skin discoloration, 15 months	Hemangioblastoma	Simple mastectomy	Died after 11 months with metastasis to lungs, liver, kidney
	18	Painful swelling, right breast, with ulcer, bleeding and bluish-purple skin discoloration, 6 months	Hemangioblastoma	Simple mastectomy	Died after 3 months
Barber and coworkers (1960)	47	Tender swelling, left breast, 6 months	Angiosarcoma	Radical mastectomy (elsewhere), excision for recurrent skin metastasis; total hysterectomy and bilateral salpingo-oophorectomy for metastasis to ovary	Died with metastasis to liver, spleen, bone, ovary, skin, 50 months after onset
	32	Tender, enlarging left breast, 15 months	Angiosarcoma	Simple mastectomy	Alive, no recurrence, 2 months after operation

*Includes 3 cases reported by Adair and Herrmann in 1946 and 2 cases by McCarthy and Pack in 1950.

of the erythrocytic sedimentation rate, and x-ray examination of the thorax, gave normal results. The value for alkaline phosphatase was 83 King and Armstrong units per 100 ml. of serum. The microscopic slides from the breast tumor removed elsewhere were reviewed and the diagnosis of angiosarcoma of the breast was reaffirmed. Further treatment did not seem warranted at this time and the patient was dismissed.

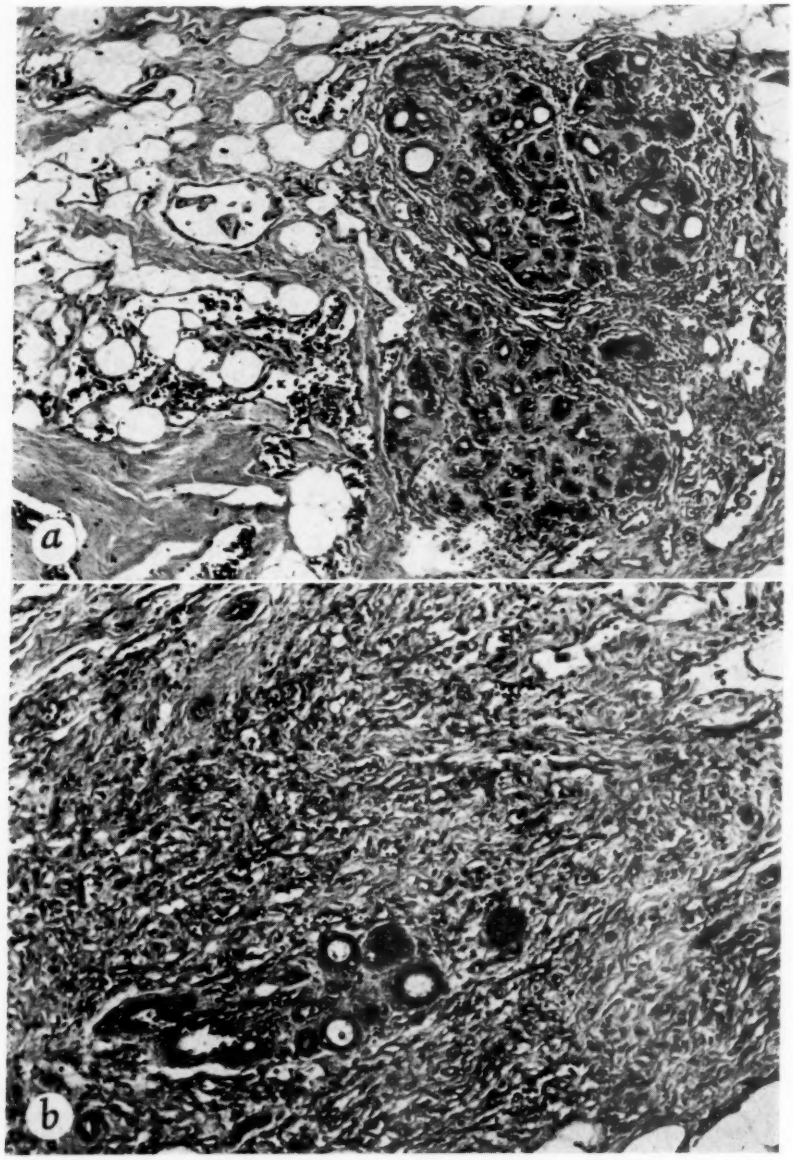

Fig. 1.—Case 1. Tissue from left axilla. *a*, Ramifying cavernous channels of angiosarcoma in fibroadipose tissue (left) which are infiltrating between lobules of breast tissue (right). (Hematoxylin and eosin; ×70.) *b*, Angiosarcoma producing diffuse, capillarylike channels which contain erythrocytes and are infiltrating an axillary mammary lobule. (Hematoxylin and eosin; ×100.)

The patient was next seen at the Mayo Clinic in January, 1958, with the chief complaint of low back pain, present since October, 1957. She also complained that she had noticed soreness in both the right shoulder and the right gluteal fold since November and December, 1957, respectively. In October, 1957, a nodule of metastatic angiosarcoma in the left arm

had been removed. Physical examination at the January visit revealed a well-nourished patient with a subcutaneous nodule 1 cm. in diameter on the medial end of the right gluteal fold. On pelvic examination a nontender, mobile right adnexal semicystic mass was felt. Laboratory studies, including total leukocyte count, urinalysis, and x-ray examination of the right shoulder, colon, and dorsal and lumbar parts of the spinal column, gave negative results. The erythrocytic sedimentation rate was within normal limits. The value for hemoglobin was 10.3 Gm. per 100 ml. of blood.

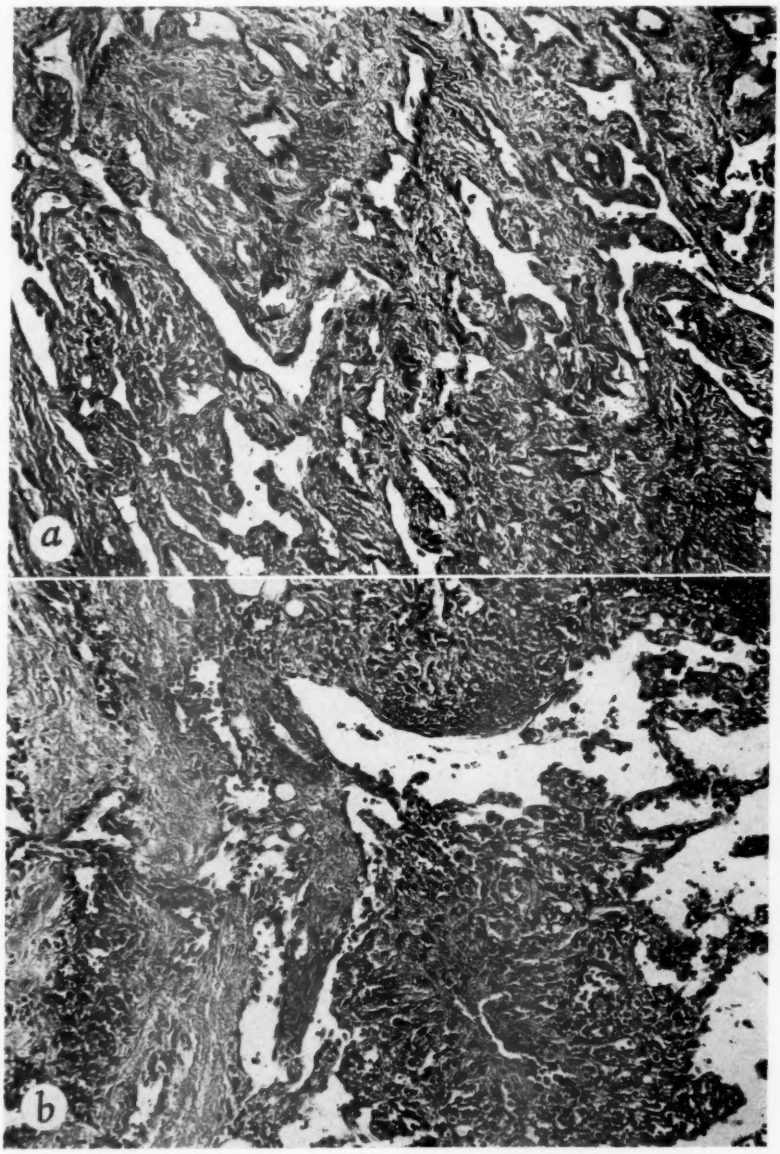

Fig. 2.—Case 1. Tissue from right gluteal fold. *a*, Metastatic angiosarcoma forming branching endothelium-lined channels of cavernous type in fibrous tissue. (Hematoxylin and eosin; ×100.) *b*, Malignant endothelial proliferation with papillary bud formations extending into large, irregular channels. (Hematoxylin and eosin; ×100.)

On Jan. 1, 1958, a metastatic lesion was excised from the right gluteal fold by one of us (J. H. P.). Examination of fresh frozen sections stained with Terry's polychrome methylene blue revealed this to be a metastatic grade 1 angiosarcoma (Fig. 2). At laparotomy a

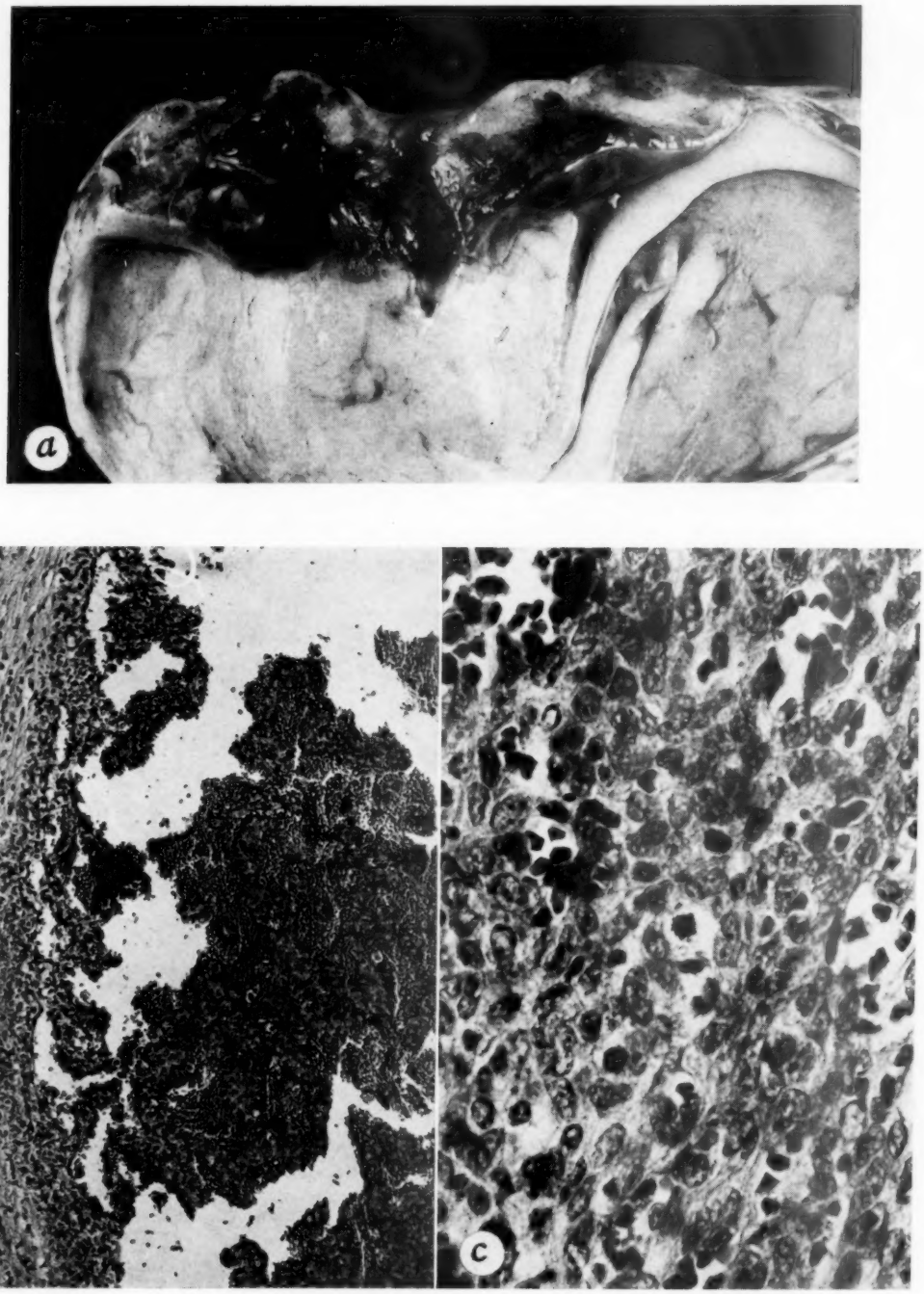

Fig. 3.—Case 1. Right ovary. *a*, Surface of metastatic angiosarcoma cut to show spongy portion of tumor with blood-filled spaces which, if spontaneously ruptured, may have resulted in fatal intraperitoneal hemorrhage. *b*, Hemorrhagic tumor composed of anastomosing cords of malignant endothelial cells projecting into and partially lining spaces which contain blood. (Hematoxylin and eosin; ×100.) *c*, More solid appearance of malignant endothelial cells, some of which are undergoing mitosis (center). Note small blood channels near top of illustration. (Hematoxylin and eosin; ×540.)

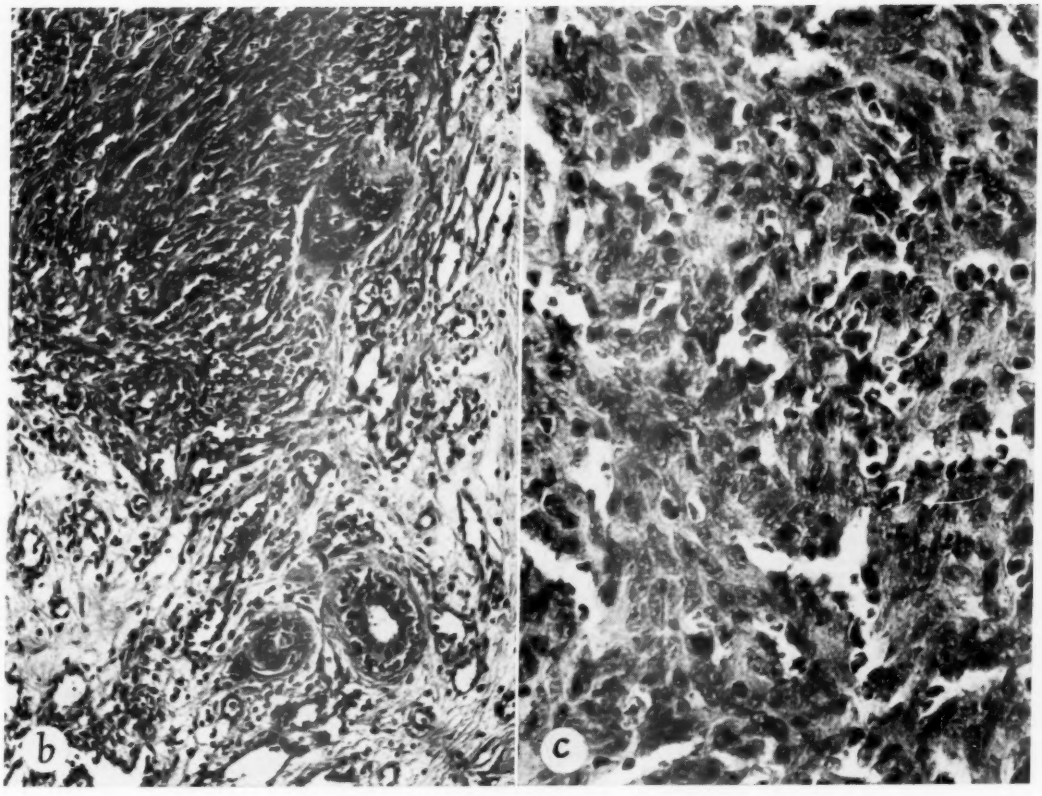

Fig. 4.—Case 2. *a*, Inferior aspect of breast with multiple transections to reveal extensive dark-red angiosarcoma within the gland. *b*, Mammary parenchyma infiltrated by malignant endothelial cells which line branching, slitlike spaces (upper left) and capillarylike spaces (lower and right). Both types of spaces contain blood cells. (Hematoxylin and eosin; ×130.) *c*, Malignant endothelial cells show moderate anaplasia and occasional mitotic figures. (Hematoxylin and eosin; ×365.)

lesion 8 cm. in diameter was identified in the right ovary. There were also a deep-seated nodule 4 to 5 cm. in diameter in the right lobe of the liver and a mass in the lower pole of the spleen. Total abdominal hysterectomy and bilateral salpingo-oophorectomy were carried out. Pathologic examination revealed a metastatic angiosarcoma 8 cm. in diameter involving the right ovary (Fig. 3). The postoperative course was uneventful and the patient received irradiation over the dorsal lumbar area prior to her dismissal.

She returned in March, 1958, because of multiple subcutaneous nodules in the right shoulder region, which were treated by deep x-ray therapy. On her last admission in June, 1958, a destructive lesion involving the distal end of the right clavicle was seen in a roentgenogram. She died on Oct. 20, 1958, and necropsy performed elsewhere showed generalized metastatic angiosarcoma.

CASE 2.—A 32-year-old white woman seen at the Mayo Clinic in September, 1959, complained of a painful enlargement of the left breast, present since November, 1958. From November until her present admission the breast had gradually increased in size and tenderness. She had at first been diagnosed clinically elsewhere as having chronic cystic mastitis, yet was referred here for evaluation of her progressive complaints.

The breast was diffusely enlarged and was moderately tender throughout. There was no change in skin color, no fixation, no edema and no dimpling of the skin, and no axillary masses were palpable. The hemoglobin determination, total leukocyte count, urinalysis, determination of the erythrocytic sedimentation rate, and x-ray examination of the thorax gave normal results. The preoperative impression was that of vascular tumor, probably of the hemangioma type, and accordingly, on Sept. 9, 1959, a primary simple mastectomy was carried out by one of us (O. T. C.).

On pathologic examination (Fig. 4) the parenchyma of the breast was found to be widely infiltrated with dark-red hemorrhagic tumor which had numerous blood-filled cystic spaces up to 1 cm. in diameter in addition to more solid, spongy tumor. The tumor was diagnosed as angiosarcoma by means of fresh frozen sections stained with Terry's polychrome methylene blue.

The patient had a satisfactory postoperative course and was dismissed from the hospital on the sixth postoperative day.

COMMENT

Angiosarcoma of the breast occurs most frequently in young women, particularly those between the ages of 20 and 30 years. Partly because of this, the lesion is usually diagnosed as benign, which leads to delay in proper therapy. The fact that the tumor occurs in a young age group is in keeping with the fact that angiosarcoma of the soft tissues in other sites usually occurs in a similar age group.

Frequently, the patient gives a history of progressive swelling of the breast of a few months' duration, the involved breast is usually found to be diffusely enlarged and tender, and the overlying skin may be red or blue, suggesting an inflammatory process. The axillary nodes are rarely palpable. Antecedent trauma to the breast, which was noted in some reported cases, may further delay therapy since the tumor may be mistaken for a hematoma.

Angiosarcoma of the breast is highly malignant. There have been no reported cures. Only 1 patient lived more than 5 years and she subsequently died from metastases.[11] Metastasis to skin, lungs, bone, and intra-abdominal viscera, which may occur early and with great frequency, takes place by way of the blood stream. Death is often related to hemorrhage from a metastatic site.

Treatment, which thus far has been generally unsuccessful, has included simple or radical mastectomy, with or without x-ray therapy, or x-ray therapy alone. Metastasis has eventually occurred, however, and death has followed on the average of 1.6 years after onset of the disease.[11] Removal of the regional lymph nodes does not seem to contribute to a more favorable prognosis because of the rarity of metastasis to lymph nodes.

With our present knowledge, apparently the only hope for cure seems to be to avoid the likelihood of confusing the lesion with a traumatic or inflammatory condition or a benign neoplasm of the breast, and to excise the primary lesion early.

SUMMARY

Angiosarcoma of the breast is distinctly rare. We found only 20 well-documented cases cited in the literature. To this number we have added 2 cases. The first is that of a 47-year-old woman who was treated surgically for metastasis from a mammary tumor and who subsequently died with metastasis 50 months after onset of the disease. The other case is that of a 32-year-old woman in whom the tumor was limited to the breast and was treated by simple mastectomy.

The type of therapy for angiosarcoma of the breast does not seem to influence the almost invariably fatal course of the disease. Apparently the only hope for a patient with this disease lies in earlier detection of the tumor and adequate therapy, usually simple mastectomy, before metastasis by way of the blood has occurred.

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INFERIOR VENA CAVA LIGATION IN THE TREATMENT OF PULMONARY EMBOLISM

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IN SPITE of the growing awareness of the problems of prophylaxis, diagnosis, and treatment, thromboembolism remains a constant source of unpleasant surprises. This is especially true when other diseases are present, especially those of a cardiorespiratory nature, which mask the clinical picture and may even furnish a false explanation of sudden death.

There seems to be no sign of a decline in the rate of death from pulmonary embolism in various hospitals over the last 2 or 3 decades.[10, 11, 16] The reported percentages are no doubt underestimations. They do not include a certain number of cases of pulmonary embolism in which postmortem examination was not deemed essential because the cause of death was thought to be some other underlying disease.

Vein ligation is the most certain method of preventing further embolization provided that the level of ligation is above the anatomic site of the thrombosis from which the embolus arises. This is always somewhat above the level of the clinical signs of the thrombosis. It must be stressed that only a minority of thromboses can be located according to clinical signs. Hence, the selection of the level of ligation must more often than not be made on the basis of deductions rather than clinical facts.

We have employed ligation of the inferior vena cava in the treatment of pulmonary embolism in all cases in which vein ligation was indicated and in which superficial femoral vein ligation had either failed or seemed unlikely to stop further embolization. Our report concerns the results of 20 cases of recurrent pulmonary emboli treated by ligation of the inferior vena cava.

MATERIAL

Twenty patients have undergone caval ligation in Tel-Hashomer Government Hospital, 1.9 within the past 3 years and one 7 years ago. Relevant data on these patients are given in Table I.

Only 5 of the patients were under the age of forty. There are few women in our series. This may be explained by the fact that the hospital does not have obstetrical patients.

Seven patients came from surgical wards and one of these (A. S., No. 16) had an additional medical problem. The other 13 came from medical wards, mostly with some form of heart disease and various degrees of congestive failure.

The operations were performed in the Vascular Surgery Unit of the hospital, and all patients were followed at the outpatient clinic for various

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TABLE I

NO.	PATIENT		AGE AT OPERATION	UNDERLYING CONDITION
1.	M. H.	(m)	24	Chronic osteomyelitis of tibia, posttraumatic
2.	N. S.	(m)	36	Recurrent deep thrombophlebitis of calf, posttraumatic
3.	H. F.	(f)	65	Bilateral varicose veins, chronic, since birth
4.	Y. B.	(m)	29	Rheumatic heart disease (combined mitral and aortic insufficiency with severe heart failure)
5.	A. R.	(m)	58	Arteriosclerotic heart disease with mild congestive heart failure
6.	Y. M.	(m)	57	Prostatectomy for benign prostate hypertrophy
7.	Y. K.	(m)	54	Prostatectomy for benign prostate hypertrophy
8.	N. A.	(m)	58	(1) Arteriosclerotic heart disease after 2 myocardial infarctions, moderate congestive failure, and (2) enlarged prostate
9.	Y. S.	(m)	57	(1) Arteriosclerotic heart disease after myocardial infarction, moderate congestive heart failure, and (2) postprostatectomy status
10.	M. C.	(m)	50	Arteriosclerotic heart disease after myocardial infarction
11.	A. U.	(m)	65	(1) Arteriosclerotic heart disease after myocardial infarction, (2) intermittent claudication, and (3) adenocarcinoma of prostate
12.	H. I.	(f)	33	Cholecystectomy for chronic cholecystitis and cholelithiasis
13.	S. S.	(m)	54	Arteriosclerotic heart disease after myocardial infarction
14.	A. M.	(m)	64	Chronic lung disease
15.	D. R.	(m)	40	Rheumatic heart disease (mitral insufficiency following commissurotomy for pure mitral stenosis, moderate congestive heart failure)
16.	A. S.	(m)	64	(1) Arteriosclerotic heart disease after myocardial infarction, and (2) hernioplasty of giant inguinal hernia
17.	Y. B. A.	(m)	57	(1) Prostatectomy for benign prostate hypertrophy, and (2) aortic insufficiency (rheumatic? syphilitic?)
18.	E. N.	(f)	34	Rheumatic heart disease (combined mitral and tricuspid insufficiency and stenosis, moderate congestive heart failure)
19.	L. Y.	(m)	52	Abscess of kidney, nephrectomy
20.	G. R.	(m)	65	(1) Open fracture of right tibia, closed double fracture of left tibia and fibula, closed fracture of left humerus, (2) concussion of brain, and (3) polyethylene tube in femoral vein

periods of time after the operation. Patients who ceased to attend the clinic were visited in their homes for an assessment of their condition at the time this report was written.

CLINICAL DIAGNOSIS OF PULMONARY EMBOLISM

The criteria on which diagnosis of pulmonary embolism was based in these patients are presented in Tables II and III. It will be noted that most signs and symptoms were nonspecific, and it was only by considering these in combination with electrocardiographic and roentgenologic findings that we could arrive at a correct diagnosis.

The majority of patients complained of shortness of breath and chest pain, usually pleuritic in character. They coughed and at one time or another brought up blood-stained sputum. A low-grade fever of up to 38° C. was usual. Signs and symptoms in the legs, when they did develop, either preceded those in the chest or appeared some time later.

Examination usually revealed râles and, in some patients, decreased breath sounds. A pleural friction rub was detected only twice, and a bloody pleural

TABLE II

NO.	PATIENT	SYMPTOMS			CHEST SIGNS					LEG SIGNS		GENERAL SIGNS			LABORATORY	
		COUGH	BLOODY SPUTUM	DYSPNEA	CHEST PAIN	RÂLES	DECREASED BREATH SOUNDS	PLEURAL RUB	PLEURAL EFFUSION	BEFORE CHEST SIGNS	AFTER CHEST SIGNS	FALL IN BLOOD PRESSURE	PULSE (100/MIN.)	FEVER	B.S.R. > 25 IN FIRST HOUR	W.B.C. > 10,000/CM.
1.	M. H.	+	+	+	+	−	−	−	−		+	−	+	+	+	+
2.	N. S.	+	+	+	+	+	+	−	Serous	+	+	−	+	+	+	−
3.	H. F.	+	−	+	+	+	−	−	−	Varicose veins		+	+	+		
4.	Y. B.	−	−	+	−	+	+	−	Bloody			−	+	+	+	−
5.	A. R.	+	+	+	+	+	+	−	−		+	−	Paroxysmal auricular fibrillation +	+	−	−
6.	Y. M.	+	+	−	−	+	+	−	−		+	−	+	+		−
7.	Y. K.	−	−	−	+	−	−	−	−			−	+	+		
8.	N. A.	+	+	+	−	+	−	−	−			−	+	+	+	+
9.	Y. S.	+	+	+	+	+	+	+	−	+		+	Paroxysmal auricular fibrillation +	+	−	+
10.	M. C.	+	+	+	+	+	−	−	−	+		−	+	+	+	+
11.	A. U.	+	+	−	+	+	+	+	−	+		−	−	+		
12.	H. I.	+	+	−	+	+	+	−	−	+		−	+	+	+	−
13.	S. S.	+	+	+	+	+	−	−	−	+		−	+	+	+	−
14.	A. M.	+	+	+	+	+	−	−	−			−	+	+	+	+
15.	O. R.	+	+	+	+	+	+	−	−		+	−	+	−		+
16.	A. S.	+	+	+	+	+	+	−	−		+	−	−	+	−	−
17.	Y. B. A.	+	−	−	+	+	+	−	−	+		−	+	+	+	+
18.	E. N.	+	+	+	+	+	+	−	−	Varicose veins		+	Auricular fibrillation (chronic) +	+	+	−
19.	L. Y.	+	−	+	+	+	+	−	−	+		−	+	+		−
20.	G. R.	−	−	+	+	+	−	−	−	Fracture +		+	+	+		
Incidence of sign or symptoms		17/20	14/20	15/20	17/20	18/20	12/20	2/20	2/20	9, 2 varicose veins	6	4/20	18/20	19/20	10/13	7/16

TABLE III

PATIENT NO.	X-RAY STUDIES: PULMONARY EMBOLISM SUSPECTED	X-RAY STUDIES: NONSPECIFIC CHANGES	X-RAY STUDIES: HELPFUL IN DIAGNOSIS	ELECTROCARDIOGRAM: PULMONARY EMBOLISM SUSPECTED	ELECTROCARDIOGRAM: NONSPECIFIC CHANGES	ELECTROCARDIOGRAM: HELPFUL IN DIAGNOSIS
1.	+	+	Yes	−	−	No
2.	+	+	Yes	+	−	Yes
3.	−	+	No			
4.	+	+	Yes	+	+	Yes
5.	+	+	Yes	+	+	Yes
6.	−	+ (repeated)	Yes	−	+	No
7.	+	−	Yes	+	−	Yes
8.	−	+ (repeated)	Yes	−	+	No
9.	+	+	Yes	+	+	Yes
10.	+	+	Yes	+	+	Yes
11.	+	+	Yes	−	+	No
12.	−	+	No	−	−	No
13.	+	+	Yes	−	+	No
14.	−	+	No	−	−	No
15.	+	+	Yes	−	+	No
16.	+	+	Yes			
17.	+	+	Yes	−	−	No
18.	−	−	No	+	+	Yes
19.	−	+	No			
20.	−	−	No	+	−	Yes
Incidence			14/20			8/17

TABLE IV

PATIENT NO.	NO. EMBOLI	SUSPECTED SOURCE OF EMBOLI	EMBOLI DURING EFFECTIVE ANTICOAGULATION TREATMENT	EMBOLI AFTER FEMORAL VEIN LIGATION	THROMBUS FOUND AT OPERATION: IN FEMORAL VEIN	THROMBUS FOUND AT OPERATION: IN INFERIOR VENA CAVA
1.	6	Ileofemoral vein	+	+	+	+
2.	2, multiple microemboli	Lower limbs			+	+ (Thrombectomy)
3.	3	Lower limbs		+		
4.	2, multiple microemboli	Unknown		+		
5.	5	Lower limbs		+		
6.	2	Lower limbs and pelvis				
7.	2	Pelvis				
8.	2	Pelvis				
9.	3	Ileofemoral vein		+	+	
10.	3, multiple microemboli	Lower limbs	+	+		
11.	3	Lower limbs and pelvis	+	+		
12.	1, multiple microemboli	Ileofemoral vein	+	+	+	
13.	3, multiple microemboli	Ileofemoral vein		+	+	
14.	Multiple microemboli	Unknown				
15.	3	Ileofemoral vein				+
16.	2	Ileofemoral vein				
17.	2	Lower limbs and pelvis				
18.	Multiple microemboli	Ileofemoral vein				+ (Thrombectomy)
19.	1, multiple microemboli	Lower limbs				
20.	2, multiple microemboli	Ileofemoral vein				
Total			4	9		

effusion only once, while in one other case there was a serous effusion. Tachycardia was present in almost all cases. One patient had chronic auricular fibrillation, while in 2 others pulmonary emboli seemed to precipitate repeated bouts of auricular fibrillation. Four patients had been in shock, 3 of them repeatedly.

Blood sedimentation rate was usually elevated, and a moderate leukocytosis was present in about half the cases.

Repeated chest x-ray studies proved to be of aid in the diagnosis of 14 out of the 20 cases. Electrocardiograms were somewhat less helpful. They were a positive aid to diagnosis 8 out of 17 times.

INDICATIONS FOR OPERATION

The various factors considered in the determination of indications for the caval ligation are summarized in Table IV.

The vena cava was ligated in 9 patients who had suffered further emboli after superficial femoral vein ligation. In 4 of these thrombectomy was carried out during operation. Four others had one or more emboli during effective anticoagulant therapy.

Four patients who showed clinical signs of ileofemoral thrombosis underwent caval ligation as a first operation. Of these, superficial femoral ligation was attempted in 2 but the thrombus at the proposed level of ligation could not be evacuated, and inferior vena cava ligation was performed immediately.

In 5 patients the pelvic plexuses of veins were suspected to be the site of origin or an additional possible site of origin. In 4 of these the caval ligation was a first operation, and in another it followed femoral ligation for a previous episode which had originated in the calf (A.V., No. 11).

Of 2 patients in whom the source of emboli remained unknown, one underwent vena cava ligation alone and one a femoral ligation as well.

OPERATION AND POSTOPERATIVE TREATMENT

The operation was performed through a right transverse incision at the level of the umbilicus. The vein was approached retroperitoneally and palpated in order to make sure that its lumen was free. In 4 of our cases the vena cava contained thrombi, and in 2 of these thrombectomy was necessary because the thrombus had extended above the level of the proposed ligation.

For a trained surgeon the uncomplicated operation may be completed in a relatively short time and it is said to be no more traumatic than an appendectomy. Most patients can withstand a general anesthetic but, when contraindicated, an epidural anesthetic may be used. In our series the latter type was used once.

In the immediate postoperative period the foot of the bed was elevated and the patient was given leg exercises, passive at first, to prevent venous stasis. Early gradual ambulation was insisted upon, with the legs in elastic bandages up to the groin at first, and later up to the knee. The patients continued to wear elastic bandages for as long as necessary in order to prevent swelling of the ankles. This period varied from 2 months to 2½ years.

As yet there is no agreement on the question of whether or not anticoagulant treatment should be given in the immediate postoperative period. The number of patients so treated in this series is too small to permit us to draw any conclusions.

IMMEDIATE RESULTS

Not one of the 20 patients, to date, has suffered a further embolus after the ligation of the inferior vena cava. Signs and symptoms disappeared within a few days and at the same time the roentgenologic appearance of the lungs improved.

Of 6 patients in congestive heart failure, 4 showed considerable improvement. One did not improve and finally died (Y. B., No. 4), and the condition of one cannot yet be evaluated because the operation was performed just recently.

A. M. (No. 14), with chronic lung disease (probably bronchiectasis), was relieved of repeated frequent attacks of chest pain, palpitations, and shortness of breath which had been superimposed upon his long-standing underlying condition.

M. C. (No. 10) required 4 weeks to recover from pneumonia which was resistant to most available antibiotics and which was presumably a result of a secondary infection of the infarcted area in the lung.

Only 2 patients died after the operation. The first (already mentioned) died on the fourth day in severe congestive heart failure which was refractory to any treatment. The second (N. A., No. 8) died of a fresh myocardial infarction, his third within 2 years, on the sixteenth day after the operation. In both cases postmortem examination revealed no evidence of fresh infarction of the lung, and no thrombosis above the level of the ligation.

IMMEDIATE AND LATE SEQUELLAE

Most patients developed some swelling of one or both legs immediately after operation, and some complained of pain. When unilateral, such swelling may affect the leg that was involved before the operation, but this is by no means the rule. It was somewhat less severe in patients who had already undergone ligation of veins at a lower level, although this was not always necessarily true. The phenomena are transient and may be minimized by proper postoperative treatment.

One patient (M. C.) suffered from a migrating superficial thrombophlebitis in the month following operation. This disappeared after suitable treatment and a subsequent thorough work-up revealed no underlying disease.

N. S. (No. 2), who was receiving anticoagulants after the operation, developed a syndrome of acute massive venous occlusion in the leg that had already been affected prior to the operation. At the same time there appeared a large subcutaneous hemorrhage of the lateral aspect of the thigh. Anticoagulants were stopped immediately. An exploration of the region of the femoral artery disclosed a normal, pulsating artery and at the same time served as decompression. Subsequently the patient recovered without further complications.

We have followed 10 of our patients for periods varying between 6 months and 7 years (average 2.25 years). All of them complained of some swelling of the ankles and a tired or heavy feeling in the legs at the end of a long day. Both subsided after the patient had lain down for a while and could be controlled by the use of elastic bandages. They were not severe enough to interfere with normal activities or occupations, as long as there were no other handicaps enforced by the underlying disease.

In most patients the superficial veins were prominent but only 2 developed varicosities which from time to time became inflamed. Venous pressure measured in 4 patients in the great saphenous vein at the ankle at different times after the operation (Table V) was within normal limits.[8, 20]

TABLE V

PATIENT	TIME AFTER OPERATION (MO.)	VENOUS PRESSURE (CM. H_2O)
2. N. S.	28	16.2
6. Y. M.	21	5.0
7. Y. K.	17	17.4
10. M. C.	7	12.5

Two patients developed hypostatic ulcers. In one (A. R., No. 5) the ulcer appeared 2 years after the operation and disappeared under conservative treatment. The second (Y. M., No. 6) is a "problem patient." He belongs to a low social class and cannot or will not follow instructions or attend our clinic. This patient has developed severe trophic changes in the skin and has 2 chronic hypostatic ulcers on the medial aspect of the ankle which do not heal.

DISCUSSION

Vein ligation, which was the original method of treatment of pulmonary embolism, lost some of its popularity with the advent of anticoagulants, especially when they became relatively inexpensive and easy to control. In time, however, it became more and more obvious that anticoagulants do not give absolute protection from emboli. Many authors quote cases of new emboli which develop in spite of anticoagulants,[5, 6, 11] and in our series there were 4 such cases (not counting another case in which prothrombin level was not satisfactory).

Whereas anticoagulant therapy might have its place as a prophylactic measure applied to a great number of susceptible patients, it is not sufficient in the treatment of patients who have already developed a pulmonary embolism. These patients have a grave prognosis,[3] and should be treated promptly and effectively. It is not enough to use a method which aspires to a percentage of success, even if this percentage is high. We owe the patients an attempt to stop embolization immediately and finally. This can be achieved by a vein ligation above the suspected site of thrombosis.

The practical choice of the level of ligation is between the superficial femoral vein and the inferior vena cava. Ligation of the common femoral or iliac veins is no easier technically and gives at least the same amount of sequellae as the caval ligation with, at most, the same protection.[13-15, 18]

Superficial femoral ligation might result in less sequellae but it also affords less protection. There are many reports in the literature of new emboli, even fatal ones, which occur after femoral ligation.[2, 5, 9, 16] In our series this happened not less than 9 times in cases in which the thrombus was believed to be below the level of ligation, or in which aspiration of the clot was carried out at operation and the lumen was thought to be left free of thrombus. Bilateral femoral ligation admittedly can be performed under local anesthesia, but the procedure usually lasts at least twice as long as caval ligation.

There is a wide variety of percentages quoted in the description of the sources of pulmonary embolism. It appears that 75 to 95 per cent of the emboli arise from thromboses situated in the drainage area of the vena cava.[1, 3, 12] Only a small percentage originate either above the level of ligation, as in tributaries of the superior vena cava. It is true also that some emboli may be given off from a fibrillating right atrium, but this can never be proved before death. A fibrillating atrium, however, does not exclude the possibility of another source of emboli in the pelvis or lower limbs, especially when the increased susceptibility of all patients in congestive failure to thromboembolic complications is considered.

Ligation of the inferior vena cava therefore seems to be the most rational and, on the grounds of wide experience, is the most effective method of treatment of pulmonary embolism. It has been opposed on the grounds that it may give rise to certain unpleasant sequellae. The question of whether these sequellae are the end results of a diseased venous system, or whether they are caused by the operation itself has not yet been finally resolved. Nonetheless, this operation is sometimes a life-saving procedure, and its benefits largely outweigh the sequellae which develop in some of the patients.

The results of our series are encouraging. When pulmonary embolism constituted the primary disease it was cured and when it complicated an underlying disease its correction brought on improvement of the basic condition, which was to be expected when the repeated insults of the cardiorespiratory system had been eliminated. This is especially true in patients in heart failure —an observation which at one time led to caval ligation as a means of treating severe heart failure.[4, 7]

Only 2 patients died after the operation, neither as a direct result of the operation but as a result of the underlying condition. All others recovered, returned to a normal way of life, and, except for 2 patients, suffered only minor inconvenience as a result of the operation.

Immediate sequellae were of minor importance and of a temporary nature. The more dramatic occurrence of acute massive venous occlusion, which was noted in 1 patient, is rare and usually amenable to treatment.[19]

Late sequellae in most patients are not severe enough to interfere with normal activity. Only 2 patients developed hypostatic ulcers and only one could not rid himself of them. It may be of some significance that this patient cooperated very poorly. Admittedly undesirable late sequellae may appear after any length of time, even after periods longer than that of the follow-up

of this series.[17] However, we can only wonder what would have been the fate of the legs after as many years without the incriminated ligation, and whether or not the patients would have lived long enough without the ligation to become the subject of such speculations.

SUMMARY

Ligation of the inferior vena cava was employed in the treatment of 20 cases of recurrent pulmonary embolism.

The criteria for diagnosis and the indications for operation are discussed. The operation is comparatively innocuous and has a low mortality rate.

Proper postoperative care reduces sequellae to a minimum. A certain percentage of undesirable sequellae is outweighed by the benefits of the correctly indicated operation.

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THE EFFECT OF OBSTRUCTIVE ARTERIAL DISEASE ON THE PERIPHERAL ARTERIAL BLOOD PRESSURE

Registrations From the Dorsalis Pedis Artery of Normal Persons and Patients Before and After Operation

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OUR problem was to study the intra-arterial pressure peripheral to obstructions in the main artery to an extremity and the effect of operation upon such pressure.

It is understandable that an obstruction in the main artery can reduce the blood flow to the peripheral part of an extremity. According to the laws of hydrodynamics, the pressure gradient across such an obstruction will depend on the degree of the obstruction as well as on the flow, and in such a way that the narrower the obstruction, the higher the gradient. With a given obstruction, this gradient will increase as the flow increases and decrease as the flow decreases.

Pletysmographic studies of the foot have demonstrated the increase in blood flow after exercise. In normal persons the flow may increase from a resting value of 3 to 5 ml. blood per 100 ml. tissue per minute to a peak of 40 ml. blood per 100 ml. tissue per minute or more under certain circumstances. Patients with femoropopliteal obstruction also show some increase in blood flow after exercise, but it is far less pronounced.

Accordingly, we would expect the gradient across an obstruction to increase during exercise of the affected limb. Since we have found the systemic arterial pressure to remain constant or rise slowly during exercise, a more or less marked decrease of the pressure distal to the obstruction should be the result.

There is also in normal arteries, however, a certain resistance to the blood flow. This resistance is dependent on the flow rate. The marked increase in blood flow in normal extremities during exercise also ought to be reflected in the peripheral arterial pressure. As a matter of fact, Doupe and associates[1] found a pressure drop in the radial artery during postexercise hyperemia. This was also confirmed by Wallace and Stead[4] for postischemic hyperemia.

In addition to studying arterial pressures, we wanted to determine whether or not there were any characteristic changes in the pressure tracings indicating the occurrence of claudication pains.

METHODS

For the study of the pressure changes resulting from femoropopliteal obstructions, we chose the dorsalis pedis artery, which was easily cannulated through a transverse incision (Fig. 1). To allow some freedom of movement,

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a 20 gauge needle in the artery was connected to the pressure transducer through a 20 cm. length of 0.76 mm. inner diameter polyethylene tubing. Two types of strain gauge transducers were used, the Elema electromanometer with Mingograph recorder or the Statham P 23 AC with Grass amplifiers and recorder.

Standing on the foot into which the needle had been inserted, the patient made toe stands at a rate of approximately 20 per minute, resting the other foot on a stool. Thus most of the body weight had to be lifted by the calf muscles of the diseased foot. This heavy work regularly provoked claudication pains within a short period of time.

Fig. 1.—The pressure transducer connected to the right dorsalis pedis artery. The patient is standing upright.

Before the exercise described was started, pressure tracings from the dorsalis pedis artery were taken from most of the patients while they were in the supine position, sitting on a stool, and standing upright.

After completion of the examination, the needle was withdrawn, the patient placed in a supine position, and the wound lightly compressed for a few minutes. This always controlled any bleeding. There were never any complications attending the healing of the wounds and we never saw any deleterious effect on the circulation of the foot distal to the incision. In the patients who were examined postoperatively, the artery was still patent with no signs of thrombosis. (All the patients were on permanent anticoagulant therapy.)

RESULTS

Fig. 2 shows the pressure tracings from 2 normal persons. After the start of toe stands, the tracings were somewhat disturbed, probably because the column of blood between the transducer and the heart was being moved up and down by the toe stands. There was a slight fall in mean pressure during the exercise.

In Fig. 3, the pressure tracing from a normal person (upper part) is compared with a tracing from a patient with an arteriosclerotic stenosis of the

common iliac artery. A reduced pulse was palpated in the groin and no pulse was found by palpation in the foot. Arteriography and, later on, operation revealed that the artery was not totally occluded. As in Fig. 2, the normal

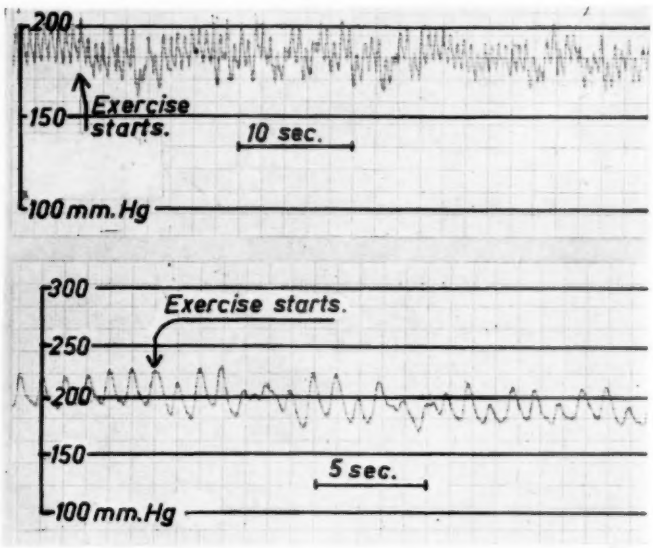

Fig. 2.—Pressure recordings from the dorsalis pedis artery in 2 normal persons during exercise (toe stands).

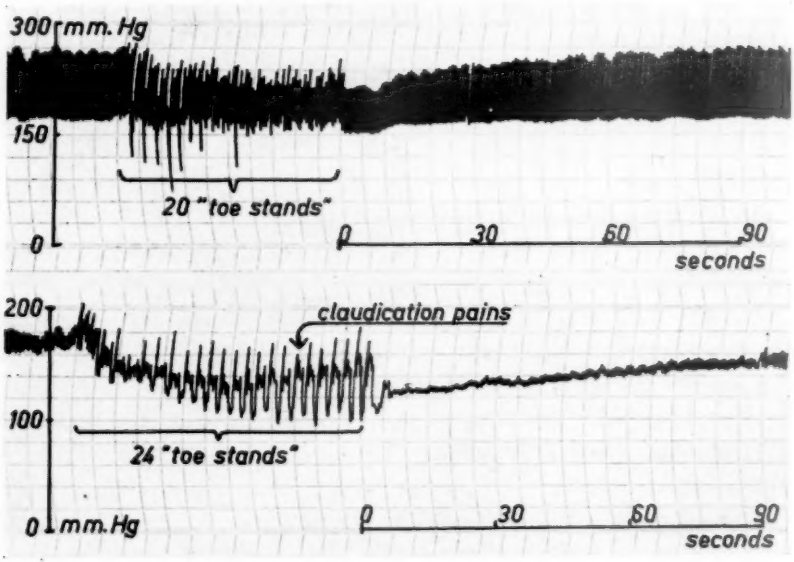

Fig. 3.—Pressure recordings from the dorsalis pedis artery in a normal person (upper curve) and from a patient with stenosis of the common iliac artery (lower curve).

person showed a small drop in the mean pressure. Particularly striking was a decrease of the amplitude as the systolic pressure drop exceeded the fall in the diastolic pressure. During the actual exercise this may be somewhat obscured, but it was distinctly seen in the period of immediate postexercise hyperemia. Then followed the period of recovery to normal pressure. The diastolic pressure

first reached the starting level after about 10 seconds of rest. The systolic pressure, however, needed about 75 seconds to regain the original resting value.

The changes which appear in the lower curve, though similar in type, far exceed those of the normal person. In addition to these changes, there was already at the beginning of the curve a lower mean pressure, and the amplitude was about one-sixth of the normal. The pressure fall during the toe stands was more marked. In the resting period immediately following, the amplitude was close to zero and the subsequent increase in amplitude and diastolic pressure was extremely slow. In this particular patient the time of complete recovery to resting values was 6½ minutes. In other patients we have found the recovery time exceeding 10 minutes. Such a case is illustrated in Fig. 4. Here the mean pressure dropped from approximately 175 mm. Hg to approximately 75 mm. Hg during the first 10 seconds of toe stands and remained at this low level as long as exercise lasted. The recovery period showed a very slow rise in mean pressure as well as in amplitude, and even a resting period of 12 minutes was insufficient to bring the pressure to the starting values. The latter curve was obtained from a patient with complete occlusion of the whole length of the superficial femoral artery.

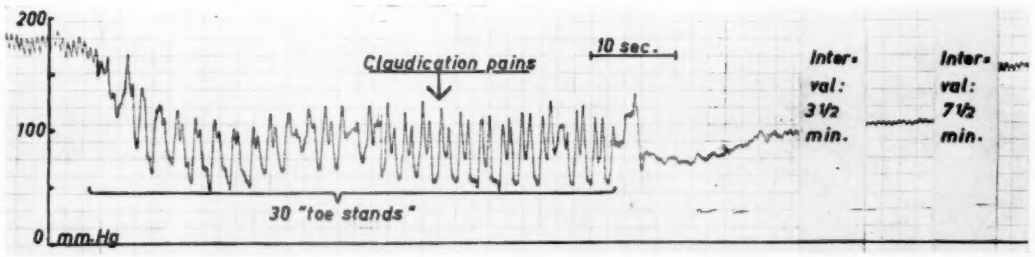

Fig. 4.—Pressure recording from the dorsalis pedis artery in a patient with complete occlusion of the superficial femoral artery.

The pair of curves in Fig. 5 represent the tracings before and after surgical intervention for a complete obstruction involving the external iliac and femoral arteries. The upper curve is very similar to the foregoing ones and the patient experienced the severe and familiar claudication pains after 42 seconds of exercise. A bypass operation was performed, with a De Bakey Dacron graft as a shunt between the common iliac and the popliteal arteries. Ten days postoperatively a further examination demonstrated a curve approaching the normal and the patient was able to perform toe stands for several minutes without suffering any leg pains. Furthermore, an improvement in mean pressure and amplitude was evident during rest at the extreme left of the lower curve. Though markedly improved, recovery time still exceeded 3 minutes.

The mean intra-arterial pressure of the dorsalis pedis artery was lower when the patient was in the supine position. The pressure, as was to be expected, increased when the patient was raised to a standing position because of the correspondingly higher column of blood between heart and foot. In normal persons the change took place almost instantaneously, but was delayed for some seconds in patients with arterial occlusive disease.

DISCUSSION

The study of the peripheral intra-arterial pressure leads to extended knowledge of the peripheral circulation in health and disease. The intralumen pressure does not in itself indicate the rate of blood flow, but it reflects the total energy level of the arterial blood stream at the point of measurement. The blood supply to the tissues depends on this energy as well as on peripheral (arteriolar) resistance.

In this connection it may be mentioned that no difference of principle exists between complete and incomplete obstruction of the main artery. As long as some of the collaterals are patent, they will have the same effect as a narrow passage through the main artery.

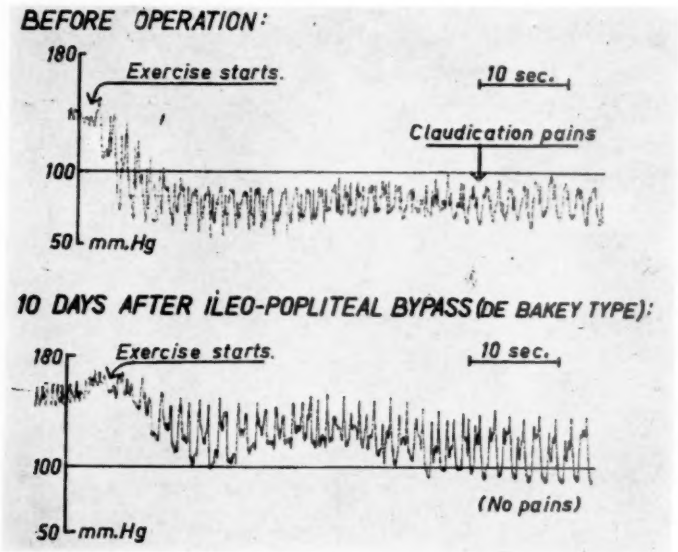

Fig. 5.—Pressure recordings before and after operation from the dorsalis pedis artery in a patient with ileofemoral occlusion.

From clinical, tonoscillographic, and plethysmographic studies[2, 3, 5] we know that the peripheral blood flow is reduced in patients with obstruction of the main artery to an extremity. It has also been shown that even in normal persons the peripheral circulation diminishes somewhat immediately after periods of exercise.

The same changes are illustrated in the pressure curves and in addition to these, our curves show what happens during the period of actual exercise, even though the exercise produces some distortion in the pressure tracings.

It is noticeable how fast the pressure drops when the blood demand of the calf musculature is increased by heavy work. Within seconds the pressure reaches a low level and remains stable as long as the exercise lasts. In some cases the pressure actually drops down to a level identical with the hydrostatic pressure of the blood column between heart and foot, and the pulse is virtually eliminated.

The obvious explanation of these findings is that the tone of the arterioles in the working muscles is very low because of the accumulation of metabolites, and the small amount of blood passing the obstruction in the main artery is rapidly drained off through these vessels.

The low pressure distally in the extremity provides a poor driving force and it must be assumed that the nutrition in this region will suffer, particularly during exercise.

As can be seen, especially in Fig. 4, a long period of time is needed to compensate for the oxygen debt to the muscles of the calf. A correspondingly long time is needed to restore the peripheral pressure to its pre-exercise level. This in turn will produce a distal ischemia with creation of another oxygen debt and, accordingly, the time necessary for complete restoration of the circulation will be even more prolonged.

The logical consequences are that heavy exercise is contraindicated in patients with occlusive arterial disease. Furthermore, when gangrene is the ultimate outcome, it starts peripherally.

To answer the question of whether or not our curves indicate the onset of claudication pains, we have been able to show that there are no distal pressure changes indicating the exact moments when these occur. Most probably these pains are best explained at present on a chemical basis, the pain being a "warning" that the accumulated metabolites have reached a certain concentration.

Registration of intra-arterial pressure is a simple and reliable method and the instrumentation is neither very complicated nor expensive. This has impelled us to use the same method for control purposes during such operations as thromboendarterectomies, bypass operations, and vascular grafting in general for the last 2 years. For monitoring, the pressure curve is displayed on a cathode ray tube during the entire procedure.

SUMMARY

Sixteen patients with obstruction of the main artery to the lower extremity were studied, by means of intra-arterial pressure measurement in the dorsalis pedis artery, during rest, exercise, and the postexercise period.

As controls, 4 normal persons were examined in the same way. Marked deviations from the normal pattern were found in all patients. Two of the patients also were studied after reconstructive vascular operations. The intra-arterial pressures at that time approached normal levels.

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EVALUATION OF ENDARTERECTOMY IN THE PRESENCE OF EXPERIMENTAL HYPERCHOLESTEROLEMIA AND ATHEROSCLEROSIS

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THROMBOENDARTERECTOMY is an established procedure in the treatment of a variety of conditions which follow atherosclerotic arterial occlusion. Recently this method has been employed in the management of ischemic coronary artery disease and presents an interesting approach to this important disorder. Although the process of healing after endarterectomy has been studied extensively, there have been few attempts to determine the results of this procedure in vessels of small caliber and in the presence of induced atherosclerosis. The present study concerns the effect of experimental hypercholesterolemia and atherosclerosis upon the course of endarterectomy. The vessels employed were small and comparable in size to the coronary arteries of the human being.

METHODS

Nine adult dogs were employed in the study. A total thyroidectomy was performed and radioactive iodine (0.6 mc.) was administered intravenously. The animals were maintained on a high cholesterol diet similar to that employed by Steiner, Kendall and Bevans.[14] The feedings contained 5 per cent cholesterol prepared by dissolving 5 pounds of cholesterol crystals in ether. This mixture was added to 100 pounds of standard laboratory dog meal† and the ether was allowed to evaporate. The animals were observed for 18 months, and during the last 6 months of this period propylthiouracil was given in a daily dose of 500 mg.

Determinations of body weight, serum cholesterol level, and systemic arterial pressure were obtained prior to the experiment and were repeated at intervals throughout the period of observation. After they had been maintained on the diet for 15 months, the animals were subjected to femoral endarterectomy. Ether anesthesia was administered and a 3 cm. segment of each femoral artery was isolated. Arterial clamps were placed above and below the segment and a longitudinal incision was made in the artery. Endarterectomy was performed by removal of the intima and a portion of the muscular layer in a segment 1 cm. in length. The incision was closed with a continuous suture

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of No. 6-0 arterial silk. This technique has been used previously in our laboratory and has been described in detail.[12] In 4 arteries the technical results at the time of operation were not satisfactory because of perforation of the wall or failure to re-establish the circulation. These vessels were ligated and were not included in the study.

Three to 4 months after endarterectomy the final weight, serum cholesterol levels, and arterial pressures were recorded. Heparin was injected intravenously

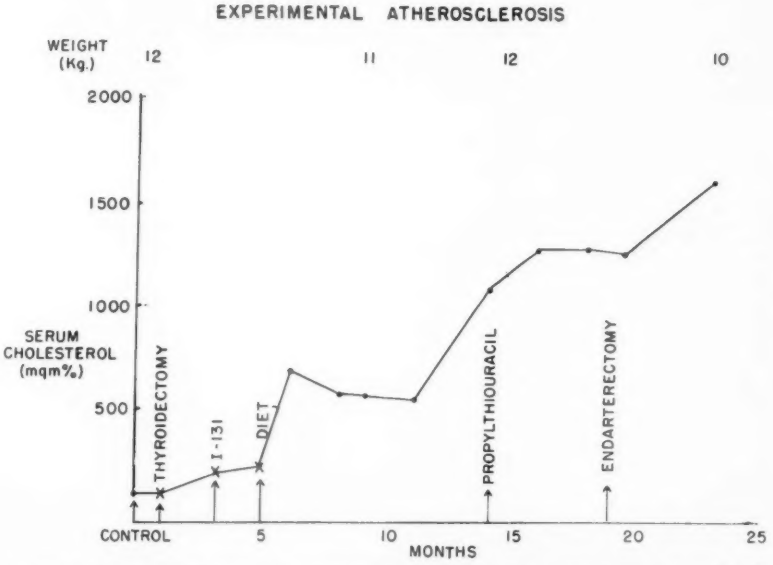
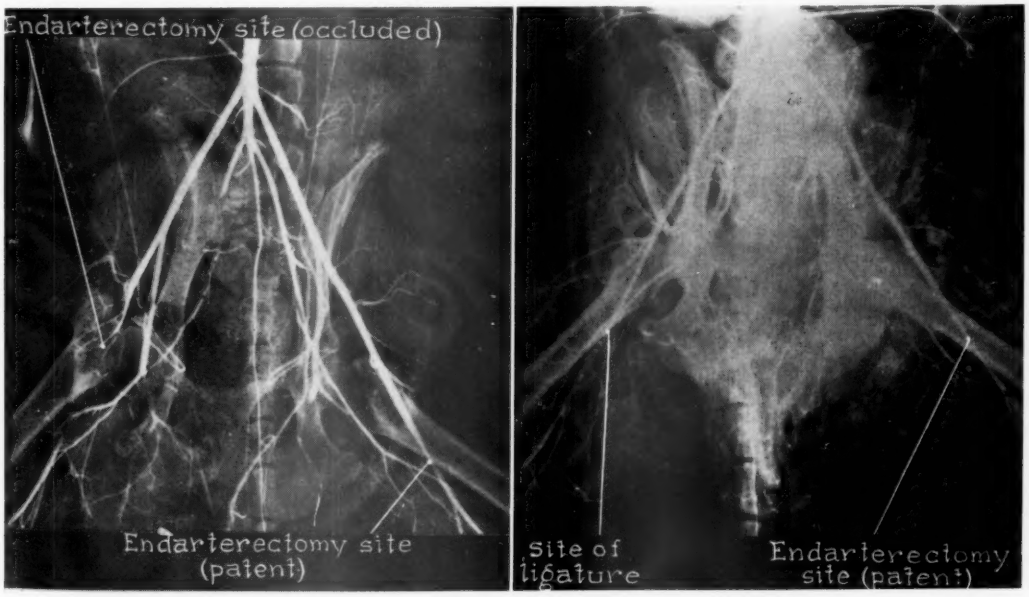


Fig. 1.—The chart illustrates the course of one of the experimental animals maintained on a high cholesterol diet.



A. *B.*

Fig. 2.—*A*, Arteriogram which demonstrates a total occlusion in the right femoral artery. The endarterectomy site in the left femoral artery showed moderate luminal narrowing. *B*, Arteriogram which demonstrates luminal narrowing at the endarterectomy site in the left femoral artery. The right femoral artery was ligated.

TABLE I. RESULTS OF EXPERIMENTAL FEMORAL ENDARTERECTOMY IN THE PRESENCE OF ATHEROSCLEROSIS

NO.	SERUM CHOLESTEROL (MG. %) CONTROL	SERUM CHOLESTEROL (MG. %) FINAL	MEAN ARTERIAL PRESSURE (MM. Hg)	FEMORAL ENDARTERECTOMY	AMOUNT OF ATHEROSCLEROSIS AT OPERATION	PATENCY OF LUMEN AT SACRIFICE	MICROSCOPIC CHANGES IN VESSEL WALL	LUMINAL NARROWING ON ARTERIOGRAM
A-3	125	1,286	115	Left	+	Open	Moderate	++
				Right	–	Occluded	Moderate	Occluded
A-4	125	841	125	Left	++	Open	Moderate	+++
				Right	–	Open	Slight	+
A-5	205	534	110	Left	+++	Occluded	Moderate	Occluded
				Right	+	Open	Moderate	++
A-7	287	785	98	Left	–	Open	Slight	++
				Right	–	Ligated	Slight	
A-8	155	769	104	Left	–	Open	Slight	+
				Right	–	Ligated	Slight	
A-9	170	1,596	113	Left	+++	Occluded	Moderate	Occluded
				Right	+++	Occluded	Moderate	Occluded
A-14	142	1,118	108	Left	+++	Open	Severe	+++
				Right		Ligated	Severe	
A-15	120	1,194	130	Left	–	Occluded	Moderate	Occluded
				Right	–	Open	Moderate	+++
A-16	115	553	128	Left	–	Ligated	Slight	
				Right		Open	Slight	++

and the animals were sacrificed. The abdominal aorta was exposed and an aortogram performed by injection of a solution of sodium iodide which clearly demonstrated the femoral arteries and their branches.

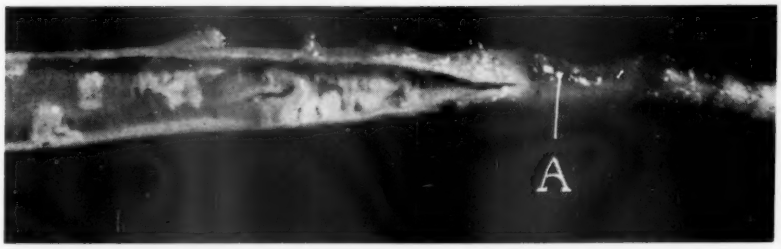


Fig. 3.—Photograph of a femoral artery which shows the gross appearance of the atherosclerotic lesions. The suture line at the endarterectomy site can be seen at *A*.

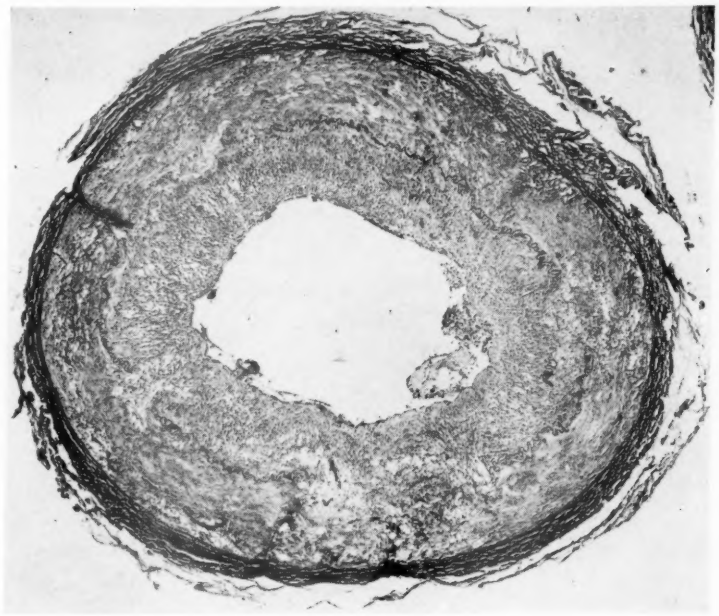


Fig. 4.—Photomicrograph of a femoral artery which shows atherosclerosis. The changes are most marked in the intimal layer The internal elastic layer is seen and is fragmented in several places.

RESULTS

The animals showed few changes in their general appearance or in their activity during the 18-month period of observation. The average weight at the beginning of the experiment was 11.3 kilograms and at the time of sacrifice 11.9 kilograms. The average control serum cholesterol level was 159 mg. per cent with a range of 115 to 287 mg. per cent. With administration of the high cholesterol diet this value gradually rose and eventually exceeded 600 mg. per cent in 7 of the 9 animals. The final average of serum cholesterol level for all the animals was 982 mg. per cent (Table I). The course of one of the animals during the experiment is illustrated graphically in Fig. 1.

After the dogs had been maintained on the cholesterol diet for 15 months, the femoral arteries were exposed and examined for evidence of atherosclerosis.

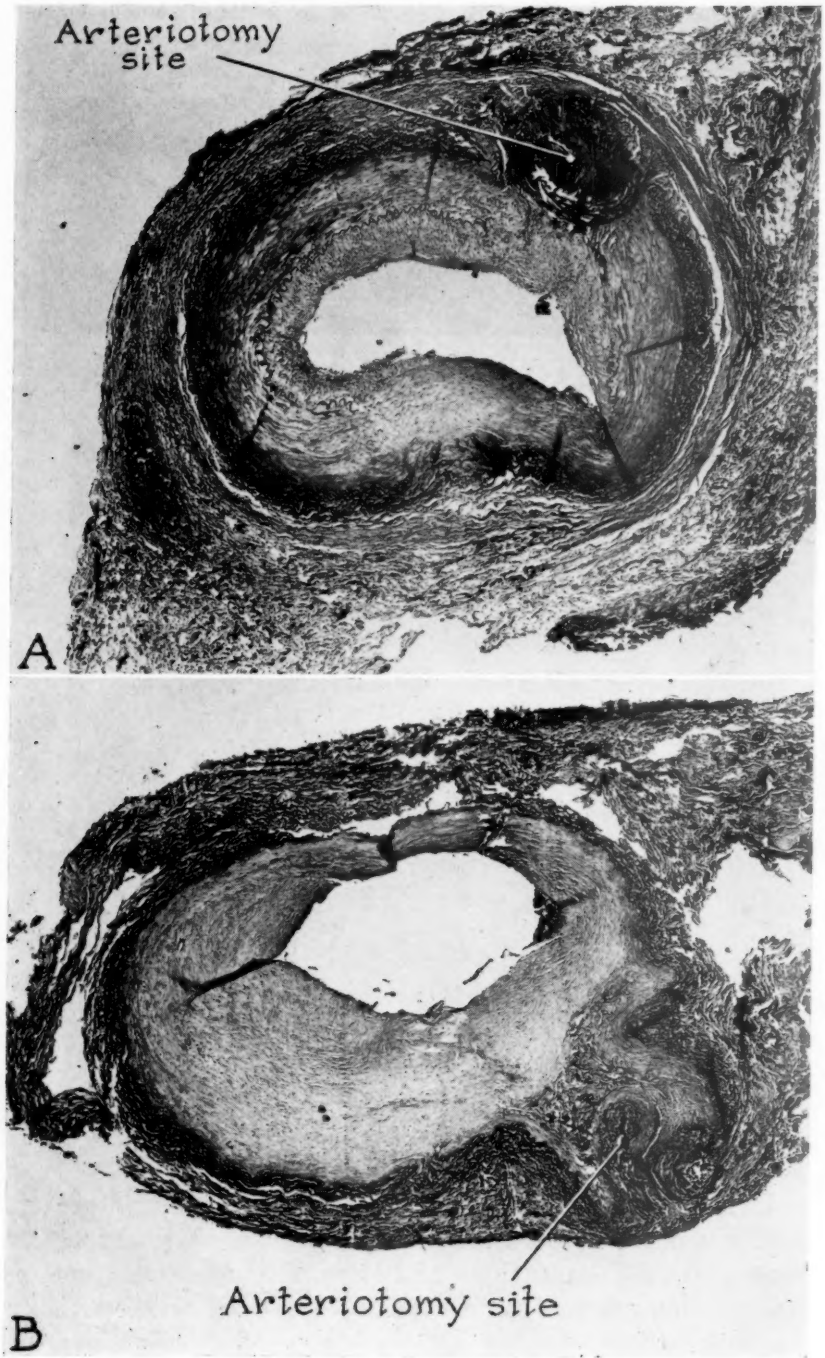


Fig. 5.—Photomicrographs of different femoral vessels at or near the site of endarterectomy (3 months after operation). *A*, Demonstration of patent lumen with a moderate degree of atherosclerosis. The site of suture and arteriotomy may be seen. *B*, Moderate luminal narrowing due to atherosclerosis. The arteriotomy site is noted.

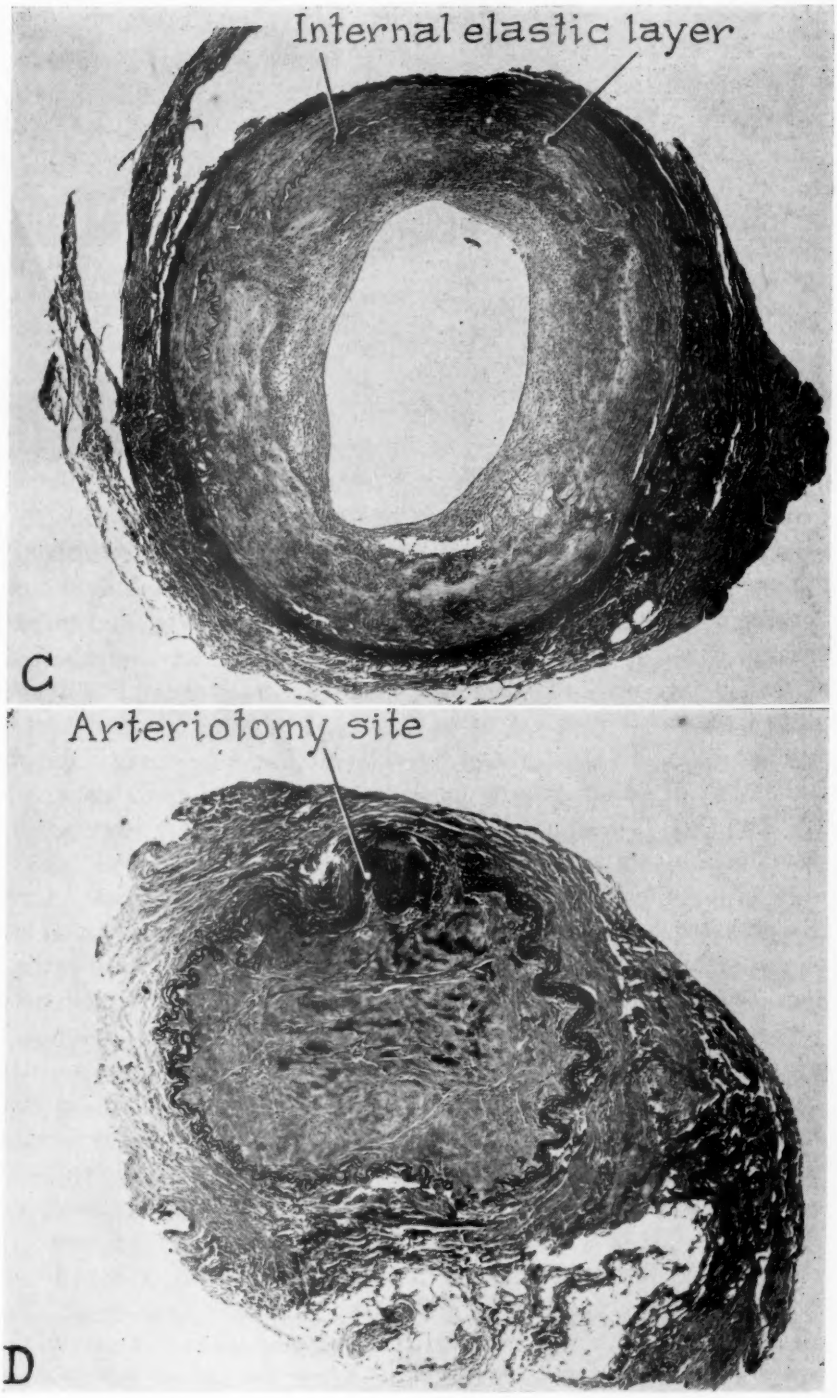


Fig. 5.—*C*, Elastic tissue stain (Verhoeff–van Gieson) demonstrating that the atherosclerosis is almost entirely limited to intimal layer. This section is taken just proximal to site of endarterectomy. *D*, Total thrombosis of lumen. (Verhoeff–van Gieson.)

In 5 of the 9 animals obvious gross changes of atherosclerosis were observed in the femoral vessels at the time of operation. After endarterectomy, the animals were maintained on the diet and the hypercholesterolemia persisted. All were sacrificed 3 months after operation. Arteriograms were obtained which showed the femoral artery to be patent at the site of endarterectomy in 9 of 14 vessels. In all instances some degree of luminal narrowing was present (Table I). Arteriograms illustrating minimal, moderate, and total occlusion are shown in Fig. 2. Gross and microscopic sections of the arteries showed the presence of atherosclerotic lesions in all vessels (Table I). An example of the gross appearance is shown in Fig. 3. The microscopic appearance of one of the femoral arteries is shown in Fig. 4 and sections through endarterectomy sites are shown in Fig. 5. Examination of the other vessels and organs revealed atherosclerotic lesions throughout the arterial system and will be discussed in a separate report.

DISCUSSION

The value of endarterectomy in the treatment of vascular obstruction has been demonstrated by a number of workers and it has been applied to many different arteries.[1-3, 6, 7, 13] This technique has been successfully employed in the management of atherosclerotic occlusion of the aorta and of the iliac, femoral, renal, carotid, subclavian, vertebral, and superior mesenteric arteries. The recent impressive work of Longmire, Cannon, and Kattus[9] has demonstrated the feasibility of direct removal of atheromas from the coronary arteries and has stimulated considerable interest in this method of management for myocardial ischemia. It is apparent that large numbers of patients are potential candidates for this procedure if it can be demonstrated that the coronary arteries remain patent after endarterectomy.

A number of factors influence the healing and subsequent development of thrombosis after endarterectomy. Several of the more important of these determinants include (1) the diameter of the vessel, (2) the extent of the obstruction, (3) the status of the vascular bed distal to the obstruction, and (4) the presence of atherosclerosis and perhaps of hypercholesterolemia. Creech and associates[5] performed an ingenious study in a group of dogs with experimental hypercholesterolemia in which aortic homografts were interposed in the abdominal aorta between the renal and iliac arteries. They observed that under these circumstances the homografts were more susceptible to the development of atherosclerosis than were autogenous grafts employed in similar animals. In a further study of this problem these workers showed that synthetic aortic substitutes behaved differently than homografts and in a group of hypercholesterolemic animals atherosclerotic lesions did not develop in the plastic prostheses although they were found in the adjacent aorta.[4] Gryska[8] performed experimental aortic intimal resection and after operation fed the animals a high cholesterol diet. At autopsy 6 months later gross atheromas were found only in the area of regenerated aortic wall. The atherosclerotic lesions were small and in no instance was there thrombotic occlusion of the aorta or significant narrowing of the lumen.

In previous studies in our laboratory it has been noted that femoral endarterectomy in normal dogs is followed by continued patency in approximately 85 per cent of the vessels.[12] The work reported in the present communication was undertaken in an effort to assess the effect of experimental hypercholesterolemia and atherosclerosis on the healing of an endarterectomy site in vessels of small caliber. Each of the animals in the group had a persistent and significant elevation of serum cholesterol. In 5 of 9 animals, gross evidence of atherosclerosis was present at the time of exploration of the femoral artery. On examination of the endarterectomy site at sacrifice, 5 of the 14 femoral arteries were totally occluded. It is of interest that the amount of atherosclerosis present at the time of endarterectomy showed a definite correlation with the subsequent degree of luminal narrowing or thrombosis. The more extensive gross and microscopic involvement was associated with a greater tendency toward occlusion (Table I). Of further significance is the fact that arteriograms demonstrated the remainder of the arteries to be patent although slight to severe luminal narrowing was present in each instance.

These studies appear to indicate that the presence of atherosclerosis alters the ultimate pathologic response to experimental endarterectomy. In each animal the serum cholesterol was maintained at very high levels during the period of healing and subsequent observation. Despite this fact approximately 65 per cent of the small vessels remained patent as demonstrated by arteriograms at the time of autopsy. It should be further noted that the femoral vessels employed ranged in diameter from 2.5 to 4.0 mm., and in correlating this study with clinical coronary disease it may be emphasized that these diameters are somewhat smaller than many arteries encountered in the human heart. It has been our observation that coronary arteries which are involved with atherosclerosis are frequently of greater total diameter than are normal vessels.[10] Furthermore, in earlier work, suggestive evidence has been obtained which indicates that coronary arteries are less likely to become thrombosed than are similar vessels in other organs under the same conditions.[11]

Although an increased tendency toward thrombosis and subsequent luminal narrowing was found in the present study, it appears significant that the majority of the vessels remained patent. The fact that these small arteries may remain patent after endarterectomy despite the presence of marked atherosclerosis lends encouragement for the use of endarterectomy in the management of atherosclerotic arterial occlusion.

SUMMARY

Endarterectomy has been performed in the femoral arteries of a group of animals with experimental hypercholesterolemia and atherosclerosis. Nine of 14 vessels studied in this manner were found ultimately to remain patent. Occluding thrombosis occurred in five. Arteriography demonstrated some degree of luminal narrowing at the site of endarterectomy in all arteries which remained patent and the extent could be correlated with the degree of atherosclerosis observed at the time of operation. The findings indicate that small

atherosclerotic arteries often remain patent after experimental endarterectomy, although reduction in the size of the lumen and development of thrombosis are significantly greater in this group than in control animals without atherosclerosis.

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A MECHANICAL HEART MASSAGER: A PRELIMINARY REPORT

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A MECHANICAL heart massager has been devised which is capable of maintaining effective circulation indefinitely during cardiac arrest in the dog. The instrument to be described consists of a power unit and a pneumatic cuff for application to the heart.

The pneumatic heart cuff was the most difficult part of the apparatus to design. Vineberg[8] has previously reported the same difficulty. The shape of the heart encourages its ejection from the cuff when pressure is applied. Drawstrings, straps, and zippers are too cumbersome to allow rapid application and can produce serious injury to adjacent structures.

A simple canine heart cuff was used successfully in animal experiments. This cuff consists of a rigid metal outer shell in the form of a cylinder. The inside surface of this cylinder is lined with a flexible rubber sheet which is sealed to the edges of the outer shell. Positive pressure applied to the space between the outer shell and inner rubber sheet causes the latter to expand inwardly (Fig. 1). Negative pressure applied to the same space causes the rubber sheet to be sucked against the outer shell (Fig. 2). In this manner, by alternation of negative and positive pressure, any object within the lumen of the outer shell is intermittently compressed and released (Fig. 3).

The power unit is a continuously operating centrifugal pump powered by a ⅓ hp motor on standard 110 v., 60-cycle alternating current* (Fig. 4). Valves at the negative and positive pressure sides of the pump are controlled by a solenoid. When the switch marked "power" is turned to the "on" position, continuous negative pressure is applied to the heart cuff. This gives a maximum inside diameter to the cuff and allows ease of application to the heart.

The initiation of intermittent positive-negative pressure is controlled by a second switch. This circuit is designed to permit the pulse rate to be varied from 40 to 140 per minute by movement of a calibrated dial. The ratio of duration of positive pressure (systole) to negative pressure (diastole) is 1 to 1. Pressure delivered to the heart cuff can be controlled within a range of from 1 to 14 pounds per square inch.

Several refinements have been added to the basic machine to facilitate monitoring the patient and to assist in recovery of spontaneous effective heart contraction. A thin metal electrode has been incorporated in the heart cuff which comes into direct contact with the epicardium. It was found necessary

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*Power unit was designed and built by Gorman-Rupp Industries, Belleville, Ohio.

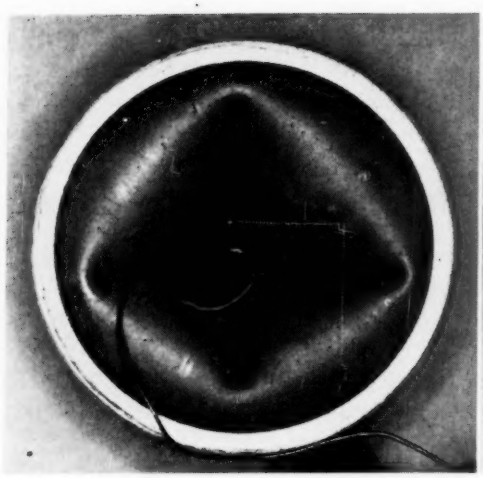


Fig. 1.

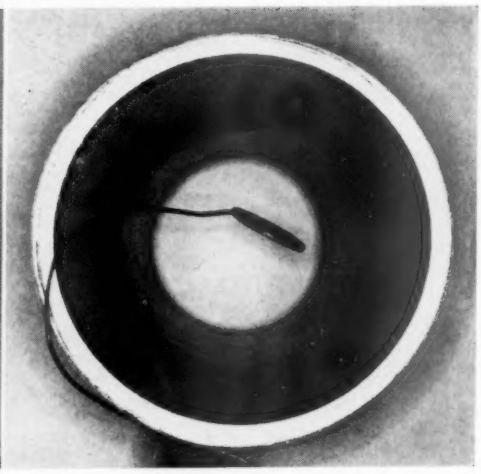


Fig. 2.

Fig. 1.—Pneumatic cuff in positive phase.
Fig. 2.—Pneumatic cuff in negative phase.

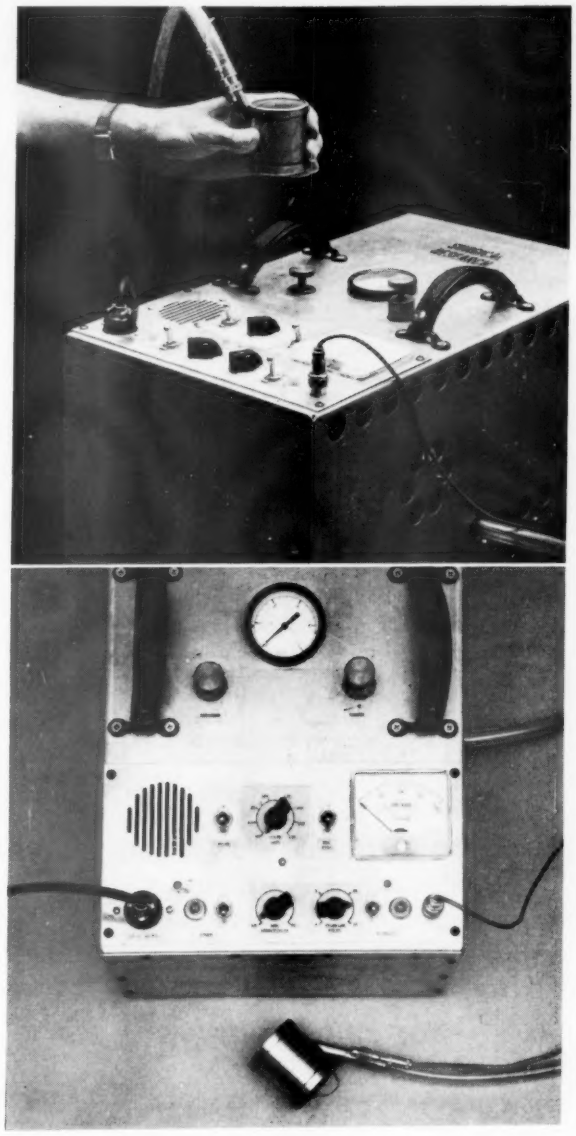
Fig. 3.—Pneumatic cuff in position on a dog's heart.

because the heart cuff distorted the standard electrocardiogram limb leads to such an extent that monitoring during massage was impossible. With the epicardial lead, monitoring is performed throughout massage. The epicardial electrode may also be used for cardiac stimulation, with stimuli ranging between 5 to 10 v., controlled by a rheostat on the face of the machine. This electrode can be used to synchronize the QRS complex with the mechanical pulse. In our experience, synchronous manual massage has been found to be most effective in returning spontaneous cardiac action.

In order to demonstrate the effectiveness of the device, a series of experiments was performed on the arrested canine heart. Long survival time was not sought in these experiments, only support of circulation after arrest until spontaneous effective cardiac action returned.

Nine animals were used. In 4 animals cardiac standstill was produced by obstructive asphyxia. In 5 animals cardiac standstill was obtained by the slow intravenous injection of 15 per cent potassium citrate. In all the animals

A.



B.

Fig. 4.—*A*, Pumping unit and canine heart cuff. *B*, Pumping unit control panel.

spontaneous cardiac action returned after mechanical massage of from 1 to 45 minutes' duration. During mechanical massage, the heart and lungs had the gross appearance of being well oxygenated. Blood pressure as measured by an intra-arterial catheter was maintained. No gross damage to the heart was apparent.

DISCUSSION

In recent years there has been an absolute increase in the incidence of cardiac arrest in the operating room.[2] Experience has demonstrated that those who survive cardiac arrest received adequate therapy within 4 to 5 minutes from the time of cessation of circulation. Ideally, the operating room offers the best chance for survival since the necessary equipment and skilled personnel are available for rapid diagnosis and therapy in such an emergency. Successful survival is highest in the patients with cardiac standstill secondary to reflex phenomena.[2] Ventricular fibrillation presents a more difficult problem, for it usually requires longer periods of massage and repeated electrical and/or chemical attempts at defibrillation. Better techniques can significantly increase successful cardiac resuscitation in such cases. Recent investigation has demonstrated that the normothermic animal can survive ventricular fibrillation for long periods with return of normal cardiac function, provided that effective blood pressure and pulmonary ventilation are maintained.[1] Manual massage has disadvantages which are apparent in laboratory experiments as well as in clinical application. There is a marked variability in the effectiveness of massage by different operators. It is not unusual to find that only one of several operators is capable of maintaining an effective blood pressure. It is also physiologically difficult for one operator to continue effective massage for longer than 30 minutes.

Structural changes in the heart result from cardiac massage. Recent studies indicate that after 15 minutes of massage, myocardial as well as epicardial damage is severe.[2, 7] A number of reports attest to the ease with which the myocardium may be ruptured during massage.[3-6] It would appear, therefore, that myocardial injury is one of the limiting factors in ultimate survival after cardiac arrest.

SUMMARY

A mechanical heart massage machine has been perfected and has functioned successfully on the dog heart. A satisfactory cuff for human application is being perfected.

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THE ASSOCIATION OF ABERRANT RENAL ARTERIES AND SYSTEMIC HYPERTENSION

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IN THIS day of diversified clinical pictures and multiplicate etiologic factors, one is tempted to consider lightly and with only passing interest new pathogenetic mechanisms of apparently minor statistical significance. Such is the case with the clinical picture of hypertension. To say that 200 separate factors contributing to hypertension have been elucidated would be a far too conservative statement. Many such factors are as yet vague and ill defined. Only in recent years has unilateral renal disease come into prominence as a clear-cut and definite source of systemic hypertension.

It is the object of this paper to point out a heretofore only scantly considered contributing factor, or even source, of unilateral renal hypertension. This infrequently recognized entity is the aberrant renal artery.

Goldblatt,[7, 8] in his classic experiments, demonstrated that a partial block of a renal artery, which produced renal ischemia, induced maintained systemic hypertension. The mechanism by which the ischemic kidney exerts its pressor effect was made known in 1942 through the work of Houssay and Braun-Menendez.[13] They showed that the ischemic kidney produces an enzymelike substance called renin, which acts on a serum pseudoglobulin, hypertensinogen, to form a pressor substance, angiotonin. This pressor substance produces a generalized arteriolar constriction and, hence, hypertension. Houssay also determined that body levels of angiotonin are regulated by the enzyme angiotensinase, which destroys angiotonin, and that this enzyme is produced by the kidneys and the intestinal mucosa. The authors were able to prove irrevocably these humoral mechanisms by transplanting a kidney to the neck of a dog. By restricting the kidney's blood supply, they were able to demonstrate the production of maintained systemic hypertension.

The clinical counterpart of the "Goldblatt kidney" may take many forms, though all have renal ischemia in common. Atheromatous deposition at the orifices of a renal artery may cause renal ischemia and hypertension.[3, 6] In the patient with severe arteriosclerosis of the distal abdominal aorta, though the renal arteries may be relatively free from sclerotic changes, a slowly progressive thrombosis may extend to include a renal artery.[21] Embolization of a renal artery, with resulting ischemia and hypertension, may occur and probably does with more frequency than is anticipated.[2, 11, 22] The infrequent renal arteriovenous anastomosis, depending upon the size, position, and duration of the shunt, may cause systemic hypertension on the basis of unilateral renal ische-

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mia.[19] Congenital saccular aneurysms of the renal artery have been described as causative agents in unilateral renal hypertension.[15] Ligation of an accessory renal artery has resulted in systemic hypertension.[18] Constriction of the renal artery by extrinsic forces may be produced by retroperitoneal tumors or pressure from an abdominal aortic aneurysm.[6]

Congenital deviations in the configuration of the renal artery from the anatomic "norm" are what may be described as "aberrant renal arteries." The "normal" renal artery has been considered to be one which originates without accessory arteries as a single vessel, at a more or less constant position opposite the renal hilus, from the abdominal aorta and which continues undivided (except for several small branches—the inferior suprarenal, the perirenal, and the ureteral arteries) in its straight course to the renal hilus.[20] The incidence of renal arterial pattern differing from this description has been reported variously from over 50 per cent[12] to 25 per cent.[4] This large difference is explained by the fact that some authors include only renal arteries with multiple origins, whereas others also include those with prehilar branching among their groups of aberrant renal arteries.

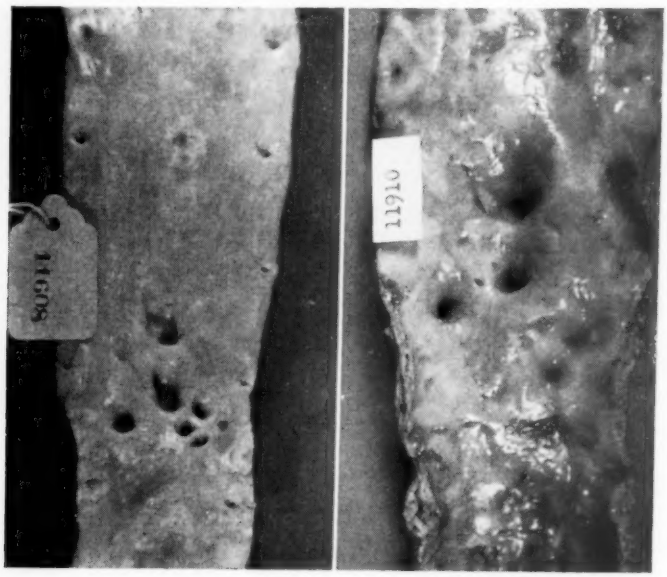

Fig. 1. Fig. 2.

Figs. 1 and 2.—Typical specimens reviewed in the series of 110 random autopsy cases. The specimen in Fig. 1 reveals 3 right renal arteries. Fig. 2 shows 2 right renal arteries. Note the severe arteriosclerotic process in the specimen in Fig. 2.

METHODS

We are accumulating a large series of random autopsy aorta specimens in an attempt to link anatomic, pathologic, and clinical findings in a broad, diversified, but cohesive correlative study. We were struck, on an initial superficial review, with the apparent high incidence of hypertension among patients who exhibited anatomic aberrations of renal arterial morphology.

We took, therefore, a random sample of 110 autopsy aorta reports from our records, utilizing written anatomic descriptions as well as lantern slides in

classifying those patients with or without aberrant renal arteries (Figs. 1 and 2). Because of a lack of information about the renal vasculature beyond 1 cm. from its aortic origin, we included as aberrant only those renal arteries which had multiple origins from the aorta. Any specimen which exhibited vessel origins which could possibly have been adrenal or gonadal rather than multiple renal arteries were included in the normal group.

We took from each patient's clinical and inpatient records the average of from 5 to 10 representative blood pressure recordings. We classified as hypertensive those patients who showed an average blood pressure of over an arbitrary level of 140/90 mm. Hg.

RESULTS

The results of the studies are shown in Table I. The over all incidence of aberrant renal arteries in this group of 110 was 25, or 22.7 per cent. Of the 110 patients, 32 or 29.1 per cent were hypertensive by our criteria. But when the group is divided into those with aberrant and those with normal renal arterial morphology, only 17.7 per cent of the normal group exhibited clinical hypertension, whereas 68 per cent of those with aberrant renal vessels were hypertensive clinically.*

TABLE I. THE ASSOCIATION OF ABERRANT RENAL ARTERIES AND SYSTEMIC HYPERTENSION (A SERIES OF 110 POSTMORTEM STUDIES)

	ABERRANT RENAL ARTERY	NORMAL RENAL ARTERY	TOTAL
Normotensive	8 (32%)	70 (82.3%)	78 (70.9%)
Hypertensive	17 (68%)	15 (17.7%)	32 (29.1%)
Total	25	85	110

The patients studied ranged in age from 8 to 87 years. Twelve were below the age of 30 years and none were hypertensive. Of these 12 patients, 3 demonstrated aberrations of renal arterial morphology. Because of the absence of hypertension among these patients in our series, we could make no correlation between age and the association of aberrant renal arteries and systemic hypertension. By excluding patients under 30 years of age, we found the incidence of hypertension in the group with normal renal arterial morphology to be 19.8 per cent and the group with aberrant renal arteries exhibited an incidence of clinical hypertension of 77.3 per cent (Table II).

TABLE II. AFTER EXCLUSION OF PATIENTS UNDER 30 YEARS OF AGE

	ABERRANT RENAL ARTERY	NORMAL RENAL ARTERY	TOTAL
Normotensive	5 (22.7%)	61 (80.2%)	66 (68.4%)
Hypertensive	17 (77.3%)	15 (19.8%)	32 (31.6%)
Total	22	76	98

Some degree of arteriosclerosis was present in the aorta of all patients over 16 years of age. In none of the patients was there frank occlusion of a renal artery. In all patients over 30 years of age, there were varying degrees of

*$\chi^2 = 23.74$; p(2-tailed) much less than 0.001.

diffuse subintimal thickening at the orifices of all visceral branches of the aorta. There was no apparent correlation in the hypertensive group between degree of arteriosclerosis by gross examination and the presence or absence of aberrant renal arteries.

Because aberrant renal arteries have been incriminated numerous times as etiologic factors in hydronephrosis, we reviewed the autopsy reports and found only 3 patients with hydronephrosis in our group. Two showed aberrant renal arteries and none were hypertensive.

We concluded, therefore, from this series of 110 random cases, that there is a significantly higher incidence of hypertension among patients who exhibit aberrant renal arteries (more than 1 in 5 individuals).

DISCUSSION

It is pertinent here to review the anatomic and embryologic considerations in the formation of the renal artery. Graves[10] demonstrated that the distribution of the arteries within the renal parenchyma is constant, for the kidney is divided into 5 distinct arterial segments between which there is no anastomosis. Each of the 5 segments is supplied by an individual segmental artery which is constant in its distribution, though variable in its origin. In a later article,[9] Graves concluded that aberrant or accessory renal arteries were, in fact, segmental renal arteries with varying origins. His conclusion is based on the embryologic evidence[5] that the mesonephros is supplied by a network of vessels, the rete arteriosum urogenitale. It is from this vascular plexus that the gonads, the mesonephros, and later the metanephros are supplied with arterial segments. Graves postulates that persistence of portions of the rete arteriosum urogenitale accounts for variations in the morphology of the origin of the renal vascular supply.

The linkage of hypertension and aberrations of the renal arterial supply has been mentioned only occasionally in the literature, which abounds in descriptions of other factors in renal ischemia and hypertension. There has been a wide sprinkling of isolated reports dealing with unusual cases of renal vascular anomalies associated with hypertension. Altman and Wayburne[1] described a 5-year-old girl who had severe congestive heart failure secondary to marked arterial hypertension. She was found to have a single, very small left renal artery supplying a kidney which was two-thirds normal size. A coarctation of the renal artery in a 24-year-old woman with hypertension was reported by Winter.[23] Surgical resection resulted in complete remission of the hypertension. Isaac and his co-workers[16] reported 2 cases in which cirsoid angiomas were the sole source of blood supply to the kidney. Both patients were hypertensive. One case was thought to be bilateral, while the other was demonstrated to be unilateral. The second patient's blood pressure returned to normal after nephrectomy.

A third case was reported by Isaac in which a 41-year-old hypertensive man was demonstrated to have several small hypoplastic arteries as the only blood supply to the right kidney. He, too, benefited from nephrectomy, and

his blood pressure returned toward normotensive levels. Howard[14] described a very similar case of the same vascular anomaly in the left kidney of a 39-year-old man.

Marshall[17] has presented to date the only previous study to appear in the literature linking hypertension and aberrant renal arteries. In his evaluation of 400 necropsy cases, utilizing essentially the same definition of an aberrant renal artery as previously described, he found the incidence of deviation from the normal to be 56 per cent. All of the aberrant arteries in his series were of 2 types. The first type involved kidneys which had multiple renal arteries with multiple origins from the aorta. The second type included kidneys which had multiple renal arteries, but the arteries stemmed from a single origin from the aorta.

Because of the paucity of clinical information on the cases considered, Marshall used the arbitrary conditions of hyaline arteriolar changes and increased heart weight to designate cases of hypertension. He found first, in a general survey, that of the patients diagnosed as hypertensive (27 per cent), more than 80 per cent had aberrant renal arteries, while only 49 per cent of the normotensive group exhibited aberrations of renal arterial morphology. In a further breakdown of the series according to age, the author was able to show no significant association of the presence of aberrant renal arteries with hypertensive signs in the age group below 40 years. But in the age group 40 years or older, almost 83 per cent of the patients with hypertensive signs exhibited aberrant renal arteries, while only 53 per cent of the normotensive group showed abnormal renal arterial structure. Exclusion of the cases of hydronephrosis and pyonephrosis did not affect the correlation though aberrant renal arteries were present in all such cases. Marshall was unable to correlate hypertension with the number or type of aberrant arteries.

That aberrant renal arteries exist in from 25 per cent to more than 50 per cent is well accepted. To note a significantly higher incidence of hypertension among patients with aberrant renal arteries is apparently a numerically important association. The absence in this series of young hypertensive patients precludes any conclusions concerning age and the association of hypertension and aberrant renal arteries. It does not, however, exclude the possibility of such a relationship.

SUMMARY

A rarely considered factor in the production of systemic hypertension by unilateral renal ischemia has been discussed. This factor is the aberrant renal artery.

The pathologic physiology of unilateral renal ischemia and possible causes of renal ischemia have been reviewed.

A series of 110 random autopsy cases was reviewed. A significantly higher incidence of hypertension was noted in the group of patients who exhibited aberrant renal arteries.

The aberrant renal artery, its anatomy and embryology, and its association with hypertension have been considered.

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FINGER STRIPPING OF VARICOSE VEINS

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THE treatment of varicose veins has passed through several stages in the past 15 years. At one time patients were lined up on platforms and tables and injected with a variety of sclerosing solutions, each solution having its own particular advocate. Many of the patients returned with recurrences and were no better than they had been originally. Many, in fact, were worse and all were certainly much poorer financially, especially if they had been subjected to further series of injections.

Next came the stage in which ligations were preferred. Ligations were performed in all sorts of ways. In the beginning they were totally inadequate because not all veins in the groin and legs were ligated, and many of the important tributaries remained patent.

Finally, multiple ligations became the most popular therapy. The word "multiple" again had many interpretations. A considerable number of patients had only the veins in the groin and at the knee ligated. Certainly many of the perforating branches were not ligated and in many cases this made the difference between a good result and a recurrence at different sites.

In the past few years preference has shifted to stripping operations, either alone or combined with multiple ligations. This constitutes the most common method used today, sometimes with several injections of small remaining veins in the postoperative period. This method of treatment has given the best long-term results.

There is, however, one objection to the stripping operations which often result in a certain percentage of local recurrences. Stripping is necessarily a blind and, at the same time, a traumatizing procedure. No matter what type of stripper is used the vein is blindly torn out and with it are torn some of the perforating veins and other tributaries. Profuse hemorrhage usually follows, which in most cases can be controlled by compression for several minutes. There is no assurance that all perforating branches and tributaries have been obtained. The extravasated blood spreads subcutaneously and may later manifest itself under the skin, remaining for a long time and presenting an ugly appearance. The perforating veins which may have remained may show up later as recurrences and require further surgical treatment. Furthermore, in patients who have had previous attacks of phlebitis and periphlebitis, the veins are brittle, do not strip easily, and are usually torn. Large sections are left which may give further trouble later on.

For several years I have utilized a technique in conjunction with stripping and ligation which has circumvented these difficulties. It may not be original, but I have never seen it reported in the literature. After the long

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saphenous vein in the groin with all its tributaries is dissected out, clamped and cut, and the proximal end doubly ligated, the distal end is grasped with mosquito clamps. It is then digitally stripped from the underlying areolar tissue. This is done quite easily because the vein is only loosely attached to this tissue. It is also dissected from the overlying skin either digitally or with a small scalpel, scissors, and peanut sponges. This procedure is continued along the course of the vein, while in the meantime the vein is pulled up. The exploring finger will easily feel the tributaries and perforating veins which join the main trunk. These can be either clamped and cut or used to indicate the position of the other veins. When the finger has reached the limit of its exploration, another incision is made, the main trunk picked up at the new incision, and the same procedure of finger and sharp dissection is carried out in all directions until another incision is found to be necessary for still further exploration. This is continued until the region of the ankle is reached. Finger dissection is also carried out with both index fingers, one in the upper incision and the other in the lower with the fingers meeting and exploring for other veins. In this manner the small veins are clamped as they are encountered and not torn. Very little bleeding results. The operation is not performed blindly with resultant hemorrhage and it is not as traumatic as the blind stripping. It is more surgical.

When a large nest of veins and varicosities is encountered in a small area it is somtimes difficult to strip or ligate these with the assurance that all the veins have been located. In such situations I have located the vein entering and leaving the nest, made an incision at these sites, clamped and cut the vein, and excised the entire area with the overlying skin and veins. Any other veins which are encountered are clamped, cut, and ligated. The skin edges are then undermined for greater mobility and are easily approximated with interrupted silk sutures. The result of this is one long incision.

This technique has given very satisfactory results and is highly recommended.

AN EVALUATION OF THE SPHYGMOMANOMETER CUFF PAIN TEST IN VENOUS THROMBOSIS

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PULMONARY emboli cause the death of approximately 1 of every 1,000 postoperative patients.[10] It is discouraging to find that venous thrombosis is freqently not recognized prior to the occurrence of a fatal pulmonary embolism. Three necropsy studies[5, 8, 11] report recognition in 46 to 53 per cent of the patients, but 3 others[3, 26, 31] report only a 6 to 26 per cent incidence of recognition. It is obvious that there is a need for a practical means of (1) predicting which patient is going to develop venous thrombosis, (2) making the early diagnosis of venous thrombosis, and (3) correctly diagnosing venous thrombosis when equivocal physical findings are present.

Several means of predicting venous thrombosis have been advocated. Various laboratory examinations for the determination of blood hypercoagulability have been described, including the heparin titration method by Waugh and Ruddick,[30] the decelerated coagulation time test by Kadish,[19] the determination of plasma prothrombin activity by Brambel and Loker[4] and Sandrock and Mahoney,[28] the clotting index method by Bancroft and Stanley-Brown,[1] the heparin tolerance test by de Takats and Fowler,[12] and the determination of fibrinogen B levels by Cummine and Lyons.[9] The value of some of these tests could not be confirmed by McClure and associates,[22] and none of the tests have been widely used, because of either their fallibility or their difficulty in performance. Barker and colleagues[2] have described simple varicosities as being a predisposing factor in 203 of 1,165 patients with venous thrombosis, and Ochsner, De Bakey, and others have shown that previous phlebitis, varicose veins, smoking, obesity, and malignant disease can also contribute to the development of venous thrombosis.[24] Although it may be true that venous thrombosis occurs most frequently in patients with such conditions, the presence of these conditions is not an adequate basis for the prediction of venous thrombosis in any individual case.

Since Homans[17] described and emphasized the concept of deep vein thrombosis of the legs with resultant pulmonary embolization, many workers have recorded the frequency with which the veins of the leg are involved. Leg veins have been found to be the source of 83 to 91 per cent of fatal pulmonary emboli when complete necropsy studies have been performed.[5, 7, 15, 26, 29] Moreover, venous thrombosis in the lower limbs has been found in 27 to 53 per cent of routine autopsies.[18, 25, 27] Unfortunately, the more dramatic clinical signs of tense swelling, marked tenderness, dilated pretibial veins, arteriospasm, or superficial phlebitis are not usually present in the early stages of deep vein thrombosis.

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Even more refined tests, such as a careful examination for calf tenderness as described by Moses[23] or dorsiflexion of the foot as described by Homans,[16] may yield equivocal results or none at all.[23]

Lowenberg[20] described a sphygmomanometer cuff pain test which he considered helpful in the prediction and diagnosis of venous thrombosis. False positive tests were described but false negative tests were not encountered. In his opinion, performance of the test never resulted in pulmonary embolism and never had a noticeably unfavorable influence on the course of the patient's disease. The test was simply performed and only a minimum of experience was needed for its interpretation. Because the test is gaining some proponents,[6] a critical evaluation of it seemed worthwhile. Therefore, this report concerns the results of the sphygmomanometer cuff pain test performed on 3 groups of patients, those with routine hospital admissions (Group I), postoperative patients (Group II), and patients in whom the status of the deep veins was known by means of phlebograms (Group III). The value of the tests in predicting venous thrombosis was studied in Group I, its value in the early diagnosis of thrombosis was studied in Group II, and its role in the correct diagnosis of venous thrombosis was evaluated in Group III.

METHODS

The sphygmomanometer cuff was applied around the foot, calf, knee, or thigh and was inflated at the rate of approximately 20 mm. Hg per second. The pressure tolerance was reached when the patient winced, grimaced, cried out, withdrew the leg, or, in the case of more stoic individuals, indicated verbally that he could tolerate no more pressure. The patient was not told that he was being tested in the initial endeavor, but was distracted by casual conversation. If a low reading resulted or the end point seemed inaccurate, the clinician explained to the patient that there would be increasing pressure as the cuff was inflated. The patient was asked to indicate when the character of the pressure changed to a sharp, pinching, severe pain. This change was characteristically abrupt. In most individuals (except the few who were "hyperreactors") the end point after the indoctrination coincided with the initial one. Repeated tests before or after instruction yielded the same end point, plus or minus 10 mm. Hg. The test was performed on both legs in one or several locations. It is worthwhile for the clinician to subject himself to the test so that he can appreciate the end point which, of course, some individuals do not experience because of a high tolerance to pressure and the limitations of the pneumatic cuff.

All of the observations were made by the authors to provide as much consistency and objectivity as possible in the evaluation of the test. The results were limited to observations on the calf unless otherwise noted. The prolixity of the name "sphygmomanometer cuff pain test" dictated use of the appellation "pressure-pain test" or "P-P test" in this study.

Group I.—Two hundred and thirty patients without suspected acute venous thrombosis were examined on admission to the surgical service of Strong

Memorial Hospital, and observations were recorded of their P-P response and existing venous disease. If P-P tolerance of less than 180 mm. Hg was obtained, the legs were examined more thoroughly (Lowenberg considered tolerance of less than 150 mm. Hg to be indicative of venous thrombosis, whereas tolerance of 180 mm. Hg or greater was normal). All patients were observed throughout their hospital stay for thromboembolic disease.

Group II.—One hundred and seven of the 230 patients received preoperative and daily postoperative examination of the legs with P-P testing. All but 7 of these patients underwent some sort of surgical procedure, which required general or spinal anesthesia.

Group III.—Thirty-seven patients, many with suspected acute deep venous thrombosis, underwent a careful examination of the legs, P-P testing, and phlebography. A total of 50 extremities were studied. The phlebograms were performed by a technique previously described.[13, 14]

RESULTS

Group I.—This group of 230 patients was examined on admission to the surgical service of the hospital, with performance of the P-P test and scrutiny of the legs. Two hundred and five of the individuals showed bilateral P-P tolerances of 180 mm. Hg or greater, and in many instances the tolerance was 300 mm. Hg. The 25 remaining patients did not tolerate pressures of 180 mm. Hg and are listed in Table I. In 13 of these 25 patients the decreased tolerance to pressure was bilateral. The coincident diseases which might be responsible for this decreased tolerance to pressure are listed in Table I.

TABLE I

COINCIDENT DISEASE	P-P TOLERANCE GREATER THAN 180 MM. Hg	P-P TOLERANCE 150 TO 180 MM. Hg	P-P TOLERANCE LESS THAN 150 MM. Hg
Chronic venous disease (varicosities and postphlebitic veins)	24	4 (1)	3
Degenerative disc disease	6	3 (2)	1
Obliterative arterial disease (requiring surgical correction)	9	1 (1)	1
Bone disease (osteomyelitis metastatic carcinoma, or arthritis)	1	—	2 (1)
Total	40	8 (4)	7 (1)
None	165	6 (5)	4 (3)
	205	14 (9)	11 (4)

Numbers in parentheses indicate the number of the total in which the decreased pressure tolerance was bilateral.

There were 11 patients with tolerances of less than 150 mm. Hg (Lowenberg positive) on admission to the hospital in a group of 230 patients, and 14 with tolerances of 150 to 180 mm. Hg. The remainder of the group had tolerances of greater than 180 mm. Hg and in many instances a pressure of 300 mm. Hg was well tolerated. Thirteen of the 25 patients with decreased tolerances had a bilateral decrease in the ability to tolerate pressure. In no instance did a patient develop a known deep venous thrombosis while in the hospital.

Group II.—Group II consisted of 107 patients whose legs were examined and on whom P-P tests were performed daily during their hospital stay. One-hundred-four of these patients underwent operations, and 98 had spinal or general anesthesia.

Ninety-eight of the patients did not develop thromboembolic disease, whereas 9 developed superficial phlebitis and are discussed separately. Seventy-six of the 98 patients tolerated pressures of 180 mm. Hg or greater throughout their hospital stay, while 22 had lower tolerances on one or several days. Seventeen of these 22 patients had P-P tolerances of less than 180 mm. Hg on admission to the hospital and 12 continued to have low tolerances, whereas 5 could tolerate pressures greater than 180 mm. Hg after the initial examination. The remaining 5 of the 22 patients developed P-P tolerances of less than 180 mm. Hg on one or more days of the postoperative period. Day-to-day changes in pressure tolerances ranged from 10 to 140 mm. Hg, while the disparity in pressure tolerance of paired limbs ranged from 10 to 220 mm. Hg. One patient with a tolerance below 150 mm. Hg in one leg on admission developed a normal P-P tolerance and later could not tolerate a pressure of 150 mm. Hg on the opposite leg. Otherwise a low tolerance test (less than 180 mm. Hg) following a low tolerance test on admission always occurred ipsilaterally. However, pressure tolerances in this group of 22 differed from those of the remaining 76 patients in that both the daily pressure tolerances and the relative tolerances of paired limbs varied more.

None of the 98 patients developed deep venous thrombosis or pulmonary emboli during their hospital stay. The patients with low readings were very closely observed. None of them developed the other more classic signs of deep vein thrombosis.

However, 9 of the total group of 107 had on admission or later developed superficial phlebitis. Two of the 9 maintained P-P tolerances of greater than 180 mm. Hg before, during, and after the acute phase of the phlebitis (one of the patients was extremely obtunded from a staphylococcal septicemia when the phlebitis occurred). In a third patient pressure tolerances were symmetrical (less than 20 mm. Hg disparity) throughout the hospital course. Tolerance was less than 150 mm. Hg on admission, rose to 300 mm. Hg, and fell to 140 mm. Hg on the day of onset of the phlebitis. All tolerances except one of 190 mm. Hg were below 180 mm. Hg in another of the 9 patients and a tolerance of 140 mm. Hg on the day of onset of the phlebitis (day 8) was greater than 3 previous pressure tolerances in the involved limb. Phlebitis appeared on day 7 in a fifth patient, but the pressure tolerance of 180 mm. Hg was higher than on the 3 preceding days. In a sixth patient there was a contralateral fall in tolerance 4 days before the onset of phlebitis with return to normal and a premonitory decrease in tolerance to 90 mm. Hg in the affected leg. One patient had phlebitis involving the thigh and the results of P-P testing of the calf were unremarkable. Phlebitis was present on admission in an eighth patient. The tolerance was 30 mm. Hg in the affected limb and 220 mm. Hg in the normal limb. There was also phlebitis on admission in a ninth patient, who had a tolerance of 160 mm. Hg in the affected limb and 280 mm. Hg

in the other. An additional patient from Group III developed superficial phlebitis above the site of a cut-down on day 3, at which time the tolerance fell to 60 mm. Hg.

In only 1 patient (the sixth) did a change in the P-P response foreshadow the onset of phlebitis. The significance of a change in the P-P tolerance in this patient was minimized by the appearance of a decreased P-P tolerance (less than 150 mm. Hg) in the opposite leg 4 and 3 days before the onset of the phlebitis. In 3 patients there was a definite unilateral decrease in pressure tolerance during the acute phase of the phlebitis but not preceding it. In the first 5 patients the P-P test proved to be of little early diagnostic value because the fall in pressure tolerance, if it occurred, was on the day of onset of the phlebitis and was bilateral. The third and fifth patients, with pressure tolerances of less than 180 mm. Hg on admission, developed tolerances of greater than 180 mm. Hg before the onset of the phlebitis. The seventh patient did not have the cuff placed over the involved segment of the vein and had normal tolerances.

Group III.—Pressure-pain tests were performed on the calf of 50 extremities from which phlebograms were also obtained. Acute deep calf vein thrombosis was present in 23 and absent in 27 extremities.

The pressure-pain readings and their correlation with other accepted signs of deep vein thrombosis in the 23 extremities with positive phlebograms are summarized in Table II. Pressure-pain responses were recorded at 80 to 140 mm. Hg in 15 extremities and at 150 to 180 mm. Hg in 3 other extremities. However, pressure-pain readings of 200 to 300 mm. Hg were observed in 5 extremities or, in other words, 22 per cent of the readings were falsely negative. Tenderness was absent in 13 per cent and Homans' sign was absent in 30 per cent of the extremities. No swelling was observed in 22 per cent of the extremities and in another 22 per cent there was less than a 1.5 cm. increase in the calf circumference. In general, low P-P readings were associated with other definitely positive clinical signs. However, in 2 patients (M. M. and S. M., Table II), tenderness was equivocal, the swelling was insufficient, and Homans' sign was negative in the presence of a strongly positive P-P test.

Twenty of the 27 extremities with negative calf phlebograms had P-P responses of 200 to 300 mm. Hg. These negative P-P results also correlated well with the physical signs and clinical impression. However, it is interesting that 2 of the 20 patients had iliofemoral venous thrombosis with localization of the thrombosis in the pelvic and thigh veins shown by phlebogram and with no calf tenderness or Homans' sign. The pressure-pain tests were performed on the calf and not the thigh.

Seven of the 27 extremities (26 per cent) exhibited false positive P-P results (Table III). In these 7 extremities the P-P responses ranged from 60 to 180 mm. Hg, but the phlebograms demonstrated normal deep calf veins and other reasons for the increased calf tenderness were present. The reasons for the false positive results included superficial phlebitis, ruptured muscles or tendons in the calf, contusion of the lower leg and, in one instance, hysteria. It should be noted that Homans' sign was also falsely positive in 5 of the 7 extremities.

TABLE II. CORRELATION OF PRESSURE-PAIN TEST WITH OTHER CLINICAL SIGNS IN ACUTE DEEP CALF VEIN THROMBOSIS AS DEMONSTRATED BY PHLEBOGRAMS

PATIENT	INVOLVED LEG (MM. Hg)	OPPOSITE LEG (MM. Hg)	TENDERNESS	SWELLING	HOMANS' SIGN
J. B.	30	180	+	+	+
L. P.	70	300	+	+	+
A. P.	80	300	+	+	+
H. G.	90	300	+	+	+
H. D.	100	240	+	+	+
R. F.	100	—	+	±	+
M. M.	100	—	0	±	0
M. I.	110	230	+	+	+
L. P.	120	300	+	+	+
W. F.	120	300	+	±	+
G. G.	130	300	+	+	+
S. M.	130	300	±	±	0
S. T.	140	260	+	+	+
L. B.	140	300	+	+	+
S. T.	140	260	+	0	+
I. G.	150	—	+	±	0
I. G.	180	—	+	0	0
B. S.	180	300	+	0	+
W. A.	200	—	0	+	0
W. A.	230	—	0	0	0
J. J.	280	300	+	+	+
A. C.	300	300	+	0	0
L. T.	300	300	+	+	+

TABLE III. REASONS FOR FALSE POSITIVE PRESSURE-PAIN RESPONSES IN PATIENTS WITH NORMAL CALF PHLEBOGRAMS

	P-P RESPONSE (MM. Hg)	TENDERNESS	SWELLING	HOMANS' SIGN	CLINICAL DIAGNOSIS
S. S.	180	+	0	0	Superficial phlebitis
M. C.	160	+	0	+	Superficial phlebitis
E. J.	140	+	+	+	Partial rupture, gastrocnemius
J. S.	120	+	+	+	Rupture, plantaris tendon
M. M.	100	0	0	0	Hysteria
M. W.	80	+	0	+	Partial rupture, gastrocnemius
L. F.	60	+	0	+	Contusion of leg

It has been noted that individuals with venous thrombosis and lowered P-P responses would eventually acquire normal pressure tolerances. Seven patients with superficial phlebitis had P-P responses of more than 180 mm. Hg at the end of a 3-week period. In fact, the P-P tolerance rose above 180 mm. Hg within 1 to 4 days after onset of the phlebitis. In 8 instances of deep vein thrombosis, 5 patients had tolerances well above 180 mm. Hg at the end of the 3-week period, while 3 had tolerances below 180 mm. Hg at 2 weeks, 4 weeks, and 8 weeks, respectively. In the latter 2 individuals, however, there appeared to be a continuation of the thrombotic process because of the patients' clinical courses.

DISCUSSION

The pressure-pain test seems of little value in the prediction of which hospital patient is going to develop venous thrombosis. Twenty-five of 230 patients had pressure-pain tolerances of less than 180 mm. Hg without clinical evidence

of venous thrombosis and none of the patients with these false positive results developed deep venous thrombosis during their hospital stay. The false positive results were associated with other local pathologic findings, including chronic venous disease, degenerative disc disease, arterial disease, and bone abnormalities. In fairness to Lowenberg's[20] contention that the test would be of value in the prediction of venous thrombosis, it should be noted that 3 of the 25 patients did develop acute superficial phlebitis. However, the phlebitis occurred at the site of indwelling venous catheters, which frequently produce a local thrombosis. In addition, 5 patients with normal pressure-pain responses on admission developed similar complications. There are also other observations which indicate that the P-P test is of meager prognostic value in the prediction of the onset of thrombosis. Old thrombosis is not uniformly accompanied by a positive P-P test. In the authors' experience, at least two-thirds of the patients with deep vein thrombosis have regained normal pressure tolerance after 3 weeks. Patients with superficial phlebitis, which responds rapidly to local therapy, have return of normal pressure tolerance in several days. This would indicate that the P-P test becomes positive when there is an inflammatory process and concomitant sensitivity of the involved tissue. Pressure over the involved area results in discomfort. As the inflammation subsides, the pressure tolerance returns to normal. We do not know of the extent of the inflammatory process associated with "bland" thrombi, but most certainly there is some inflammation associated with the organization of the clot and the incorporation of it into the vein wall. Perhaps the special situation of thrombosis secondary to a bacterial invasion of the vein wall in bacteremia would result in a decreased tolerance to pressure premonitory of the thrombus formation. Though most patients with thrombosis may show a lowering of pressure tolerance at some time during the evolutionary sequence, this change may often be evanescent, and the cuff must be applied over the involved segment of vein to register a positive test. Thus, it is not reasonable to conclude that the P-P test could be a really useful presage for venous thrombosis.

The daily performance of the P-P test on postoperative patients also proved to be of little value. Twenty-two of 107 patients had false positive results at some time during their hospital stay. Seventeen of these had false positive results on the day of admission. The other 5 patients showed wide variations in the day to day readings and in the relative readings of the 2 legs, which cast further doubt on the value of the test in the early diagnosis of deep venous thrombosis.

The most objective evaluation of the P-P test was made in the extremities of 50 patients, many with suspected deep venous thrombosis, who were studied by phlebography as well as by a complete clinical evaluation. In this group, 22 per cent of the patients with known deep venous thrombosis showed false negative results. These results are in sharp contrast to Lowenberg's findings of no false negative results in the study of 350 patients. In fairness to the test, it should be noted that Homans' sign was more frequently falsely negative, and swelling was of little value in diagnosis when the thrombosis was localized to the deep calf veins. Actually, a careful examination for calf tenderness provided the most

reliable of the clinical signs and probably serves to point out the basic fallacy of the P-P test. The test was proposed, in our opinion, to measure objectively a subjective symptom, tenderness. The response of any particular person to the blowing up of a sphygmomanometer cuff on the leg, or to palpation of the leg, is going to be determined by that person's pain threshold, as well as by any local pathologic findings that might be present. Since tenderness proved to be a more reliable sign than the P-P test, one must assume that the examiner's interpretation of whether or not tenderness was present was a more valuable method of diagnosis. There may be isolated cases, when tenderness is equivocal, in which a positive P-P test on one leg and a contralateral normal response may be of value in the correct diagnosis.

False positive results were obtained from the examinations of 26 per cent of the patients with no deep venous thrombosis. These results once again demonstrate the inability of the test to differentiate deep venous thrombosis from superficial phlebitis, muscle strains or tears, contusions, or hysteria.

We agree with Lowenberg that the examination is a benign one. However, 2 patients did develop thromboembolic problems after the performance of the test. In one patient deep vein thrombosis appeared after performance of the P-P test. The patient gave a history of bilateral deep venous thrombosis which had occurred 26 years previously. He developed a massive iliofemoral thrombosis after being in bed for 10 days and having several P-P tests. At necropsy several days later, he was found to have had metastatic bronchogenic carcinoma without evidence of pulmonary embolism. Another patient was examined before the inception of this study. He was admitted with swelling of the right leg and had daily P-P studies until his death, 8 days after admission. The clinical diagnosis was deep vein thrombosis. Therapy consisted of Parenzyme administration and no anticoagulants were given. Postmortem examination revealed multiple small pulmonary emboli and one large embolus. Although a causal relationship between performance of the test and these undesirable sequelae is possible, the events are also within the limits of the natural history of the disease.

CONCLUSIONS

The sphygmomanometer cuff pain test of Lowenberg was evaluated to determine its role in (1) predicting deep venous thrombosis, (2) the early diagnosis of venous thrombosis, and (3) the correct diagnosis of venous thrombosis.

1. Two hundred thirty patients were examined on admission to the hospital and 25 were found to tolerate pressures of less than 180 mm. Hg pressure. None of these patients had or developed deep venous thrombosis. The reasons for the false positive results included chronic venous disorders, degenerative disc disease, arterial disease, and bone disorders.

2. One hundred seven patients were examined daily throughout a hospital stay. In no instance did the P-P test assist in the establishment of an early diagnosis of deep venous thrombosis. In addition, there were occasionally wide

variations in the daily responses, and false positive results were observed in 22 patients.

3. Fifty extremities, many with suspected deep venous thrombosis, were studied by phlebography, as well as by careful clinical examination. The pressure-pain test results were falsely negative in 22 per cent and falsely positive in 26 per cent of the cases in which the correct diagnosis was reasonably certain. Reasons for false positive results included acute superficial phlebitis, muscle tears, contusion, and hysteria.

4. A careful examination for tenderness would seem to be of more value in the diagnosis of deep venous thrombosis than the performance of the P-P test, since the modality measured is still a subjective sign dependent upon the patient's pain threshold. In some patients with equivocal tenderness a positive pressure-pain test on one leg, with a normal response on the other may assist in the correct diagnosis of thrombosis.

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ADENOCARCINOMA OF THE APPENDIX

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CARCINOID tumors of the appendix are relatively common. One is encountered in approximately every 500 routine appendectomies,[1] but unlike carcinoid tumors of the ileum, they rarely metastasize and for this reason they have been excluded from this review. A distinction between carcinoid tumors and the other types of carcinoma of the appendix is important because the latter have a more serious prognosis and in some cases require a more radical surgical procedure.

Primary adenocarcinoma of the appendix is an uncommon lesion for which there is no pathognomonic sign or symptom, but it has been encountered with increasing frequency since histologic examination of all surgical specimens has become an established procedure. The malignant mucocele and the colonic type of cylindroma are both adenocarcinomas, although they have a different pathogenesis and vary in their degree of differentiation. A distinction between malignant mucocele and the colonic type of adenocarcinoma is further justified because of the difference between their natural histories.

MALIGNANT MUCOCELE

The concept that some mucoceles of the appendix may be malignant was suggested by Waugh and Findley[37] and supported by Woodruff and McDonald.[38] Carleton[4] and others, however, believe that many of the morphologic changes described by Broder as occurring in grade 1 papillary adenocarcinomas are largely due to pressure distribution and increase in the number of goblet cells. Nevertheless, the term "malignant mucocele" appears to define a type of lesion which possesses certain more or less constant clinical characteristics. It is estimated that such tumors are found once in every 4,300 appendectomies.

A malignant mucocele is usually characterized grossly by a dilated appendix containing a gelatinous mucoid material, or by a ruptured appendix and pseudomyxoma peritonaei. The regional nodes are rarely, if ever, involved. Rosenfeld[30] reports that the nature of pseudomyxoma peritonaei is somewhat in question. Rare reports have been found in which this lesion was associated with mucoceles of the gall bladder and persistent omphalomesenteric ducts. When pseudomyxoma peritonaei is surgically encountered in males, a mucocele, benign or malignant, of the appendix must be ruled out, whereas in females preexisting pseudomyxomatous cyst adenocarcinoma of the ovary must be excluded. In some instances, flecks of calcium in the walls of mucoceles or pseudomyxomatous cyst adenocarcinoma may suggest the diagnosis.

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In cases in which the tumor has perforated the appendix, the cecum or terminal ileum or both may be imbedded in a gelatinous mass. In many cases the structure of the appendix is so disrupted that it cannot be identified. The characteristic histologic pattern of a malignant mucocele is that of a well-differentiated papillary adenocarcinoma occurring in a dilated appendix, the lumen of which is distended by mucinous material.

A review of the literature suggests that malignant mucoceles rarely metastasize via lymphatics or by the blood stream. The main complication is transcoelomic dissemination if the tumor ruptures. It is known, however, that patients with pseudomyxoma peritonaei may live for many years.

COLONIC TYPE OF ADENOCARCINOMA

The colonic type of adenocarcinoma of the appendix is exceedingly rare, and because the signs and symptoms are nonspecific, it is not surprising that there is no recorded case in which the diagnosis was made prior to operation. The incidence is difficult to determine but 1 case has been estimated to occur in about every 30,000 appendectomies. The tumors are relatively slow-going and often remain confined to the mucosa for a long time. As the disease progresses, the tumor extends into the muscularis and serosa and eventually into adjacent organs, particularly the cecum and terminal ileum. The primary site of the tumor is only of academic importance when the cecum is involved, and the tumor may then be considered with adenocarcinoma of the cecum in regard to treatment and prognosis. Only cases of carcinoma confined to the appendix at the time of operation are included in this review.

The anatomic structure of the appendix is important to remember when considering the spread of the disease. There are regions where the enveloping longitudinal and circular muscle layers are deficient and submucosa and serosa abut one another.[13] The lymphatic plexus of the organ has free communication between the various coats. Injected material can be shown to pass from submucosa to subserosa, but not in the opposite direction.[13] The main lymphatic and venous drainage of the appendix is essentially that of the cecum and terminal ileum. Thus almost any node of the entire upper or lower ileocolic chain may be a primary drainage area for the appendix. Once a primary lesion is found in the appendix, the drainage areas on the anterior surface of the third portion of the duodenum and above the origin of the ileocolic artery should be checked for gross involvement. Little evidence is available in this material to indicate the incidence of diffuse lymphatic and venous spread prior to involvement of the cecum or terminal ileum proper. If there is no recognizable evidence of submucosal invasion, we believe the incidence of distal metastatic spread to be low. This would seem to be substantiated by the excellent survival rates reported in patients with appendectomy alone, and in the patients who underwent right hemicolectomy subsequent to the initial operation and the unsuspected diagnosis of adenocarcinoma. There was no recorded evidence of spread to the regional lymph nodes in the surgically removed specimens of this series.

The colonic type of adenocarcinoma of the appendix is histologically identical to adenocarcinomas elsewhere in the colon. Some of these tumors arise in

polyps within the lumen of the appendix. There may be no gross abnormality, or there may be an acute appendicitis secondary to obstruction of the lumen by the enlarging tumor. Other tumors begin in the mucosa of the appendix and are unassociated with the formation of polyps. A distinction between these two types of the colonic type of adenocarcinoma is of practical significance. The prognosis in cases of carcinomatous change within polyps in which there is no invasion of the polyp stalk is more favorable and a more conservative surgical procedure is justified in these cases than when the polyp stalk has been invaded or when the tumor arises within the mucosa of the appendix and is unassociated with the formation of a polyp.

The basic histologic pattern is that of an adenocarcinoma which may vary in its degree of differentiation and in its stromal response. The tumor may be confined to the mucosa without penetration of the basement membrane. In the absence of detectable invasion, the diagnosis of carcinoma depends on cytologic alterations in cell size, shape, staining characteristics, and numerous mitotic figures, as well as lack of uniformity in glandular structure. Our review would indicate that in these cases an excellent prognosis can be expected with appendectomy alone.

Unlike the malignant mucocele, which spreads primarily by peritoneal dissemination, the colonic type of adenocarcinoma spreads by direct extension and by invasion of lymphatics and veins. For this reason, we believe that patients who show evidence of early invasion will have a less favorable prognosis than those in whom the lesion is restricted to the mucosa even though a right hemicolectomy is performed.

DISCUSSION

This review is based on an analysis of 84 cases of malignant mucocele and the colonic type of adenocarcinoma that have been reported, in addition to 4 new cases. Three of the latter were studied at the Hamilton General Hospital, Hamilton, Ontario, and 1 was studied at the Buffalo General Hospital, Buffalo, New York. The purpose of this review was to determine the course of adenocarcinoma of the appendix in order to be better able to establish criteria for treatment. The diagnosis in each case was based on histologic examination of surgical material. Only the cases in which the primary tumor was confined to the appendix at the time of the first operation were included.

Twenty-one cases were malignant mucoceles. Eleven of the patients were males, 9 were females, and in 1 case the sex of the patient was not recorded. The average age was 53 years. The youngest patient was 29 and the oldest 83 years of age. Unlike other types of adenocarcinoma of the colon, the disease shows no significance in incidence in males and females. The preoperative impression in 16 of the cases in which an unruptured mucocele was found at the time of operation was acute appendicitis in 8, unidentified mass in the right lower quadrant of the abdomen in 3, carcinoma of the ovary in 2, and inguinal hernia in 1 (Table I). In 2 cases the preoperative diagnosis was not recorded. An appendectomy was performed in all these patients and 3 received postoperative radiation. There were no immediate operative or postoperative deaths. Six patients survived 5 to 29 years after operation and showed no evidence of

recurrence. Four patients survived 1 to 4 years. One patient died of his disease and 1 was found to have recurrent disease. Two patients died of unrelated causes, while 2 were lost to follow-up.

TABLE I. REPORTS IN THE ENGLISH LITERATURE OF MUCOCELES UNRUPTURED AT THE TIME OF OPERATION

AGE	SEX	SYMPTOMS	OPERATIVE PROCEDURE	ADDITIONAL TREATMENT	COMMENT
Hilsabeck.—					
37	M	Right inguinal hernia	Appendectomy	X-ray treatment	No recurrence in 29 years
66	F	Acute appendicitis and mucocele	Appendectomy and partial cecotomy	X-ray treatment	No recurrence in 13 years
75	M	Cecal mass	Right hemicolectomy	—	No recurrence in 1 year
78	M	Acute appendicitis	Appendectomy	—	No recurrence in 3 years
50	M	Cecal mass	Right hemicolectomy	—	No recurrence in 2 years
45	M	Ruptured retrocecal appendix	Appendectomy	—	No recurrence in 7½ years
61	F	Mucocele of appendix and pseudomyxomatous ovary	Appendectomy and right salpingo-oophorectomy	X-ray treatment	No recurrence in 2 years
65	M	Retrocecal appendix	Appendectomy	—	Died 10 years later
42	F	Cystadenocarcinoma of right ovary	Appendectomy and right oophorectomy	Total hysterectomy 15 years later	Died 1 year after second operation
56	F	—	Appendectomy and bilateral oophorectomy	—	No recurrence in 26 years
59	M	Acute appendicitis	Appendectomy	Operation 2 years later for appendiceal stump	Died 2 years later, lymphoblastoma
66	M	Acute appendicitis	Appendectomy	Laparotomy 10 years later	No evidence of recurrence at laparotomy
43	F	—	Subtotal hysterectomy and appendectomy	—	—
Slack.—					
51	F	Right lower quadrant mass	Right hemicolectomy	—	Alive and well, 5½ years
Nardell.—					
83	F	Subsiding appendiceal abscess	Right hemicolectomy	—	—
Lesnick.—					
41	—	Acute appendicitis	Appendectomy with partial cecotomy	—	Ovarian mitosis within 7 months

TABLE II. REPORTS IN THE ENGLISH LITERATURE OF RUPTURED MUCOCELES

AGE	SEX	SYMPTOMS	OPERATIVE PROCEDURE	ADDITIONAL TREATMENT	COMMENT
Hilsabeck.—					
46	M	Ruptured mucocele, pseudomyxomatous peritonaei	Appendectomy	X-ray treatment	Died at 11 months, pseudomyxoma peritonaei
48	—	Ruptured mucocele	Appendectomy	Operation 6 years later and x-ray treatment	Died 2 years after second procedure
55	M	Mass and multiple implants about the cecum	Right hemicolectomy	—	No evidence of disease after 2 years
62	F	Acute appendicitis	Appendectomy	Laparotomy 5 years later	Died 3 years after second procedure, pseudomyoma peritonaei
Waugh.—					
49	F	Appendicitis	Bilateral salpingo-oophorectomy and appendectomy	—	Died within 10 months

In 5 cases a ruptured mucocele was discovered at laparotomy (Table II). The preoperative clinical impression was ruptured mucocele of the appendix in 2, acute appendicitis in 2, and an unidentified abdominal mass in 1. In 3 cases a simple appendectomy was performed, in 1 an appendectomy and bilateral salpingo-oophorectomy, and in 1 a right hemicolectomy. Two patients received postoperative radiation. One patient showed no evidence of recurrence 2 years later, 2 died within 1 year, and 2 within 8 years. In all terminal cases the disease was directly or indirectly attributable to the patients' demise. Radical operation or radiation did not seem to alter the prognosis in this group.

Sixty-three patients had a colonic type of adenocarcinoma of the appendix. Six of the tumors were restricted to polyps within the lumen of the appendix (Table III). The remainder involved the appendix proper (Table IV). Twenty-two patients were females, 36 males, and in 5 cases the sex was not recorded. The average age in both sexes was 48 years. The youngest patient was 22 and the oldest 79. In 35 cases the preoperative diagnosis was acute appendicitis, in 3 cases chronic appendicitis, in 7 cases right lower quadrant pain, and in 5 cases an unidentified mass was present in the right lower quadrant of the abdomen. In the remaining cases, perforation, carcinoma of the cecum, and abdominal distention were each diagnosed once. Ten patients were asymptomatic and the appendix was removed at laparotomy for an unrelated condition. A simple appendectomy was performed initially in all patients except 4, 3 of whom underwent a right hemicolectomy and 2 in whom the initial procedure is unknown. Forty-two of these patients received no further treatment. There were 5 recorded deaths in the immediate postoperative period. Two patients died of unrelated causes. Fifteen patients showed no recurrence 2 to 15 years after operation, 3 had a recurrence in less than 1 year, and in 11 patients a follow-up record was not available. Fourteen patients underwent

TABLE III. REPORTS IN THE ENGLISH LITERATURE OF COLONIC TYPE ADENOCARCINOMA OF THE APPENDIX RESTRICTED TO A POLYP

AGE	SEX	SYMPTOMS	OPERATIVE PROCEDURE	ADDITIONAL TREATMENT	COMMENT
Hilsabeck.—					
69	F	Extracecal mass	Appendectomy and partial cecotomy	—	No evidence of recurrence after 9 years
36	F	Fibroids	Myomectomy and appendectomy	Hysterectomy for fibroids 15 years later	No evidence of recurrent disease at laparotomy
46	M	Duodenal ulcer	Gastrectomy and appendectomy	—	Died 9 years later of multiple sclerosis
51	F	Chronic cholecystitis	Cholecystectomy and appendectomy	—	No evidence of recurrence after 3 years
Nardell.—					
54	F	Left lower quadrant pain	Right hemicolectomy	—	—
Clarke.—					
70	M	Right lower quadrant pain	Appendectomy	—	Alive and well after 4 years

a right hemicolectomy soon after their first operation. Of these patients, and including the patient who had a hemicolectomy as an initial procedure, only 1 is shown to have recurrent disease. One patient with the colonic type of adenocarcinoma received radiation, but died within 7 months.

CONCLUSIONS

Although this series is not large, certain conclusions regarding treatment appear justified.

1. The malignant mucocele may be adequately treated by simple appendectomy with a reasonable expectation of cure, but every precaution should be taken to prevent peritoneal spread.

2. If the carcinomatous change in the colonic type of tumor is restricted to a polyp and the base is not involved, only simple appendectomy need be performed.

3. If there is evidence of submucosal invasion or local extension, a right hemicolectomy is indicated, except in patients with widespread metastasis.

4. Adenocarcinomas of the appendix can often be completely excised. These tumors usually grow slowly and are often recognized early, for they frequently cause an associated appendicitis which occasions their removal. Although the factors in the individual case must be evaluated, hemicolectomy offers the patient showing mucosal invasion the best chance of cure.

SUMMARY

Adenocarcinoma of the appendix is an uncommon lesion. Malignant mucocele and the colonic type of adenocarcinoma are variants of the same

TABLE IV. REPORTS IN THE ENGLISH LITERATURE OF COLONIC TYPE ADENOCARCINOMA OF THE APPENDIX

AGE	SEX	SYMPTOMS	OPERATIVE PROCEDURE	ADDITIONAL PROCEDURE	COMMENT
McGregor.*—					
74	F	Acute appendicitis	Appendectomy	—	Died 1 year later of breast cancer
37	F	Acute appendicitis	Appendectomy	Partial right colectomy	Well after 8 years
26	M	Acute appendicitis	Appendectomy	Right hemicolectomy	Well after 1 year
McGregor†.—					
41	F	Chronic appendicitis	Appendectomy	—	Well after 15 years. No evidence of recurrence
Frauenthal.—					
43	F	Appendicitis	Appendectomy	Laparotomy, 2 years	No recurrence after laparotomy
Lesnick.—					
51	—	Cachexia	Laparotomy	—	—
36	—	Acute appendicitis	Appendectomy	Right hemicolectomy	No evidence of recurrence, 3 years
57	—	Appendiceal abscess	Right hemicolectomy	—	Well after 2 years
—	—	Acute appendicitis	Appendectomy	Iliocolostomy 3 years later	Recurrent disease in regional nodes and cecum
Schuldt.—					
64	M	Acute appendicitis	Appendectomy	—	Metastatic lesions biopsied within 10 months
Slack.—					
67	F	Right lower quadrant mass	Appendectomy and drainage of peritonitis	—	Died within 6 days, peritonitis
51	M	Acute appendicitis	Appendectomy	Right hemicolectomy	3½ years, alive and well
43	M	Appendicitis	Appendectomy	Iliotransverse colostomy 1 month later	Died within 1 year of disease
Chomet.—					
40	M	Chronic appendicitis	Appendectomy	—	—
22	F	Leukocytosis and tenderness	Panhysterectomy and appendectomy	—	—
65	M	Acute appendicitis	Appendectomy	Partial colectomy	—

*Hamilton General Hospital, Hamilton, Ontario.
†Buffalo General Hospital, Buffalo, N. Y.

TABLE IV. (CONT'D)

AGE	SEX	SYMPTOMS	OPERATIVE PROCEDURE	ADDITIONAL PROCEDURE	COMMENT
Young.—					
36	M	Acute appendicitis	Appendectomy	Ileotransverse colostomy	No recurrence of symptoms, 2 years
Rabinovitch.—					
54	F	Chronic cholecystitis cholelithiasis	Cholecystectomy and appendectomy	Right hemicolectomy	Symptom free, 1 year
52	F	Fibroid	Total hysterectomy and appendectomy	Right hemicolectomy	Symptom free, 8 years
62	M	Strangulated femoral hernia	Right femoral herniorrhaphy and appendectomy	—	12-year survival
48	M	Acute appendicitis	Appendectomy	Right hemicolectomy	5-year survival
Dent.—					
39	M	Right lower quadrant pain	Appendectomy	—	—
65	M	Right lower quadrant pain	Appendectomy	—	Autopsy 2½ months later, no evidence of neoplasm
58	M	Acute appendicitis	Appendectomy	Laparotomy, 6 weeks	Died after second surgical procedure. No evidence of additional tumor
Gerber.—					
65	M	Perforated viscus and peritonitis	Appendectomy	—	Died, peritoneal carcinomatosis, 10 months
Heine.—					
53	M	Appendicitis	Appendectomy	—	—
Sieracki.—					
46	M	Acute appendicitis	Appendectomy	Lysis adhesions 3 months later	Died after second operation with peritoneal involvement
60	F	Carcinoma of cecum	Appendectomy	—	Alive and well in 4 years
59	M	Incidental appendectomy	Appendectomy	X-ray treatment	Died within 7 months
64	F	Acute appendicitis	Appendectomy	Laparotomy	No evidence tumor at laparotomy, alive and well, 2 years
63	M	Acute appendicitis	Appendectomy	—	Died, 3 months
51	F	Incidental appendectomy	Appendectomy	—	Alive and well in 18 months
47	M	Appendectomy	Laparotomy 5 months later	—	Died, peritoneal carcinomatosis

TABLE IV. (CONT'D)

AGE	SEX	SYMPTOMS	OPERATIVE PROCEDURE	ADDITIONAL PROCEDURE	COMMENT
Sieracki.—Cont'd					
65	M	Acute appendicitis	Appendectomy	—	Alive and well in 9 months
Thibaudeau.—					
—	F	Subacute appendicitis	Appendectomy	—	Died within 72 hours
Phillips.—					
56	F	Intestinal obstruction	Appendectomy	—	—
Montgomery.—					
49	M	Right lower quadrant mass	Appendectomy	—	Alive and well in 2 years
Blumenkopf.—					
62	M	Appendicitis	Appendectomy	—	—
Rosenblatt.—					
60	M	Appendicitis	Appendectomy	—	Alive and well in 2½ years
Wright and Smith.—					
61	M	Abdominal distention	—	—	Died 2 days after admission, metastatic nodules in pleura and lungs
Heilborn.—					
—	—	Acute appendicitis	Appendectomy	Right hemicolectomy	Tumor in lymph nodes
Lee.—					
57	M	Acute appendicitis	Appendectomy	Right hemicolectomy	Alive and well in 4 months
Mark.—					
72	M	Acute appendicitis	Appendectomy	Iliocolostomy in 5 weeks	—
Hughes.—					
40	F	Acute abdominal symptoms	Appendectomy	—	Alive and well in 5 years
Kaplan.—					
72	F	Acute appendicitis	Appendectomy	—	Invading mesoappendix
Sillery.—					
55	M	Appendicitis	Appendectomy	—	Alive and well in 14 years
34	F	Acute appendicitis	—	—	—
Smith.—					
72	M	Acute appendiceal abscess	Appendectomy	—	Died within 5 years of disease
French.—					
79	M	Acute appendicitis with perforation	Appendectomy	—	Died cerebrovascular accident, no evidence of disease

TABLE IV. (CONT'D)

AGE	SEX	SYMPTOMS	OPERATIVE PROCEDURE	ADDITIONAL PROCEDURE	COMMENT
Lowton.—					
72	M	Right lower quadrant pain	Appendectomy	—	Died of abscess within 7 weeks
58	F	Appendiceal mass	Appendectomy	Right hemicolectomy, 1 week	Alive and well in 2 years
60	M	Acute appendicitis	Appendectomy	—	—
Fleming.—					
42	F	Incidental appendectomy	Appendectomy	Right hemicolectomy, 6 weeks	Alive and well, 2 months
Bosman.—					
26	M	Acute appendicitis	Appendectomy	—	Alive and well, 8 months
Crile.—					
48	M	Acute appendicitis	Appendectomy	—	Alive and well, 3 months
McCampbell.—					
52	M	Acute appendicitis	Appendectomy	Right hemicolectomy, 1	Alive and well in 1 year
Clarke.—					
53	M	Right lower quadrant pain	Appendectomy	—	Alive and well in 18 months

tumor, but merit distinction because of their different natural history and prognosis. Twenty-one cases of malignant mucocele and 63 cases of the colonic type of adenocarcinoma are reviewed. Simple appendectomy is adequate treatment for unruptured malignant mucoceles and the colonic type of adenocarcinomas of the appendix which arise in polyps and show no invasion of the polyp stalk. A right hemicolectomy offers the best prognosis for other varieties of the colonic type of adenocarcinoma.

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MANEUVERABILITY OF THE HAND AND THE HEMOSTAT

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"Many of the American centres have this in common—a change of emphasis in their surgery from technique to chemistry. Consequently one sometimes gets the impression—no doubt erroneously—that some of the young surgeons are *chemists practicing surgery!*"

Harold C. Edwards
King's College Hospital Gazette, Summer, 1951.

AFTER one eliminates from the practice of surgery the many ancillary additions and innovations which have made it such a successful form of the healing art, one inalterable fact still remains—in order to practice surgery, one must be, in spite of everything else, a skilled technician.

While most of us will grudgingly admit this truism, our literature and our teaching institutions appear to belie the admission. We rightly devote volumes to diagnosis, perioperative care, electronic adjuncts, artificial organs, new procedures, and new instruments to facilitate surgery. Yet almost no attention is directed at innovations facilitating manual dexterity.

Time, short and well spent, is still the essence in surgical procedures.[1] Anything that will aid the surgeon in the rapid, though gentle and careful, manipulation of tissue with ease and confidence deserves a place in our surgical armamentarium.

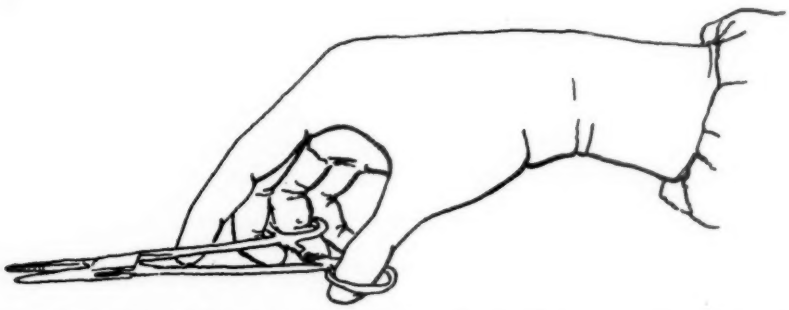

Fig. 1.—The commonly accepted method of manipulating loop-handled surgical instruments. This technique is quite efficient when the surgeon is working with superficial tissues.

The universally accepted method of grasping the looped handles of surgical instruments, such as the hemostat, is by insertion of the thumb and second or third finger into the loops so that the point is directed more or less in line with the forearm (Fig. 1). This technique is quite efficient when the tissue at which the instrument is aimed is located superficially. The extended forefinger provides considerable stability to the instrument, the hand does not obscure the operative field, and the limited flexion with ulnar and radial deviation of the wrist is adequate for good maneuverability.

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Fig. 2.—Use of pronation of the forearm and flexion of the wrist to reach deep tissues. Note that as the field becomes deeper and narrower, the position becomes more uncomfortable and the instrument's point is obscured by the operator's hand.

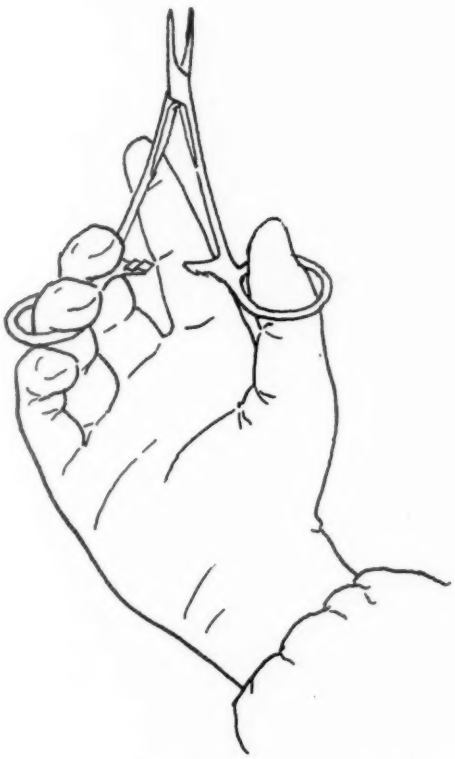

Fig. 3.—Deep tissues are reached through supination of the forearm and marked extension of the wrist. Again, as the point is extended deeper into the wound, the view is obscured and much maneuverability of the instrument is lost.

But when the tissue desired for instrumentation is located well within the depths of a surgical wound, as in deep abdominal and thoracic procedures, this technique becomes cumbersome, awkward, and less well controlled. Use of increased wrist flexion (Fig. 2) and internal rotation at the shoulder (so that the

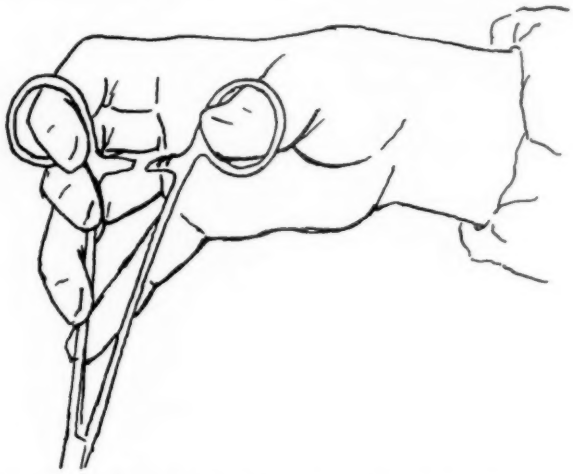

Fig. 4.—The method of grasping instruments utilized by the author in all but the most superficial procedures. The point is extended downward at a right angle from the hand. The hand assumes a very comfortable position and is capable of a high degree of maneuverability and control over the instrument.

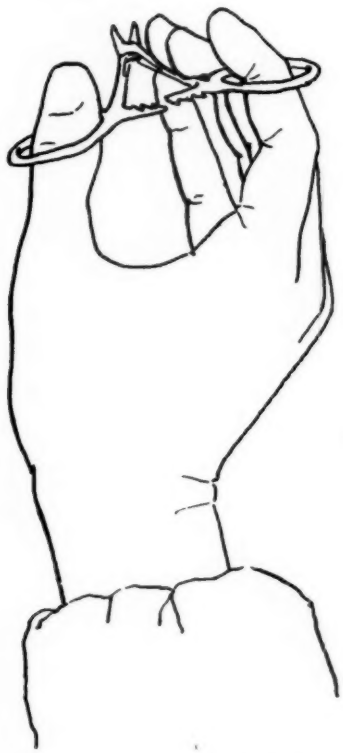

Fig. 5.—Note that the point of the instrument readily extends to the wound's depths without necessity of contortion on the operator's part. The view is unobstructed at all times.

bent elbow is pointing straight up) puts the surgeon's hand in his own field of view and has been known to expedite contamination of the surgeon's gown by the mask, glasses, and other face parts of a second assistant.

An alternative application of the accepted technique, when the field is deep and narrow, is use of supination of the forearm and extreme extension of the wrist so that the point of the instrument is down (Fig. 3). The palm then obscures the field of view, and much control over the instrument is lost, though one has a better chance of remaining aseptic than with the first technique.

Some surgeons have found it imperative on occasion to wield a hemostat in the manner shown in Fig. 4. The instrument is grasped through its finger loops by the thumb and forefinger. The remaining 3 fingers are used to stabilize the forefinger side of the instrument. The hand and wrist conform very nearly to the "anatomic position of function," and the forearm is in very comfortable midrotation. The instrument is quite stable in the hands of a surgeon accustomed to the technique. The point is highly maneuverable and extends naturally to the wound's depth without necessity of contortion by the operator.

We have come to adopt this technique of handling instruments almost exclusively in all but the most superficial procedures. Excellent control of the instrument at all times is possible, one may view an unobstructed field (Fig. 5), and the instrument may be handled easily with speed, comfort, and dexterity. The described method of grasping instruments is readily adaptable to almost all clamps, straight or curved, and to scissors as well.

During the past 6 years, observation of this technique by our residents has prompted many of them to practice with it during spare time. Almost all who have become familiar with it now use it by choice.

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EFFECT OF TRANSFUSION ON BLOOD VOLUME IN STARVED AND UNDERNOURISHED RATS

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WITH THE TECHNICAL ASSISTANCE OF NELLE SICHER

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AVERAGE blood volume in the state of health has usually been assumed to be the normal value for the determination of blood volume in all situations. Since the introduction of the concept of chronic shock in 1947 by Clark and associates,[1] the use of this value as the optimal one for blood volume in cases of disease associated with weight loss has been questioned. It has been shown in this laboratory[3] that tolerance to whole blood loss in starved and chronically undernourished rats bears a straight-line relationship to weight at the time of bleeding. Further, it has been shown[2] that tolerance to hemorrhage and other traumas involving blood volume component alterations seems to be related to the specific demand made upon the blood volume and the status of the component of the blood volume upon which the demand is made.

The value of preoperative blood transfusion of the malnourished patient has not been quantitated. The present study was undertaken to establish whether or not the response of starved or undernourished animals to whole blood infusion differs from that of normal animals. The magnitude and duration of the effect of infusion on the blood volume, plasma volume, and red cell mass were determined.

METHODS

Male albino rats of the Holtzman Farms were used. The animals were individually housed in an air-conditioned laboratory for 4 days prior to the beginning of an experiment. They were fed Purina laboratory chow and were given water ad libitum until a specific interval before each experiment when food alone was withheld. At the starting time of each experiment, each rat was weighed to the nearest half gram on a triple-beam balance and this value was recorded as initial body weight.

Experiment 1. Whole Blood Infusion During Acute Starvation.—

Acute starvation alone (control): Food was withheld after 7:00 A.M. of the day on which the experiment was begun and the animals were weighed at noon for initial body weight. Weights were 260 to 310 grams. No additional food was given, but water was allowed ad libitum. Starvation weights were

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recorded at noon of each day thereafter. The total number of rats was divided into 8 groups of 6 animals each. In 1 group total blood volume, plasma volume, and red cell mass were determined at the start of starvation by means of Cr^{51}.[2] The same measurements were made in succeeding groups at 24-hour intervals. In this manner, daily determinations were made for 7 days after the start of starvation.

Measurements of radioactivity dilution and the hematocrit of arterial blood permitted the calculation of the circulating red cell volume. The hematocrit of carotid blood was considered to represent the total body hematocrit. The total blood volume was calculated from the measured red cell volume on the basis of arterial hematocrit. Duplicate hematocrit determinations were made in capillary tubes spun in a Phillips-Drucker microcentrifuge. Plasma volumes were calculated as the differences between the total blood volumes and the red cell volumes.

Acute starvation with whole blood infusion: Food was withdrawn at 7:00 A.M. of the day on which the experiment was begun and the animals were weighed at noon for initial body weight. Weights were 280 to 350 grams. No additional food was given, but water was allowed ad libitum. Animals were weighed at noon of each succeeding day and mean starvation weight was found to be 73.9 per cent of initial weight on the fifth day of starvation. At this time the difference between initial body weight and actual body weight was calculated. An amount of whole blood equal in milliliters to 5 per cent of the difference in weight was infused through a polyethylene catheter inserted into a femoral artery. Calculated in this way, the blood added was adequate to theoretically provide an ideal blood volume based on initial body weight. The amount infused was greater than 20 per cent of the actual circulating volume at the time of the infusion.

Determinations of total blood volume, plasma volume, and red cell mass were performed on groups of 6 to 8 animals at infusion time (uninfused, starved control), and at 4, 24, and 48 hours after infusion.

Fed controls with whole blood infusion: Food was withdrawn in the late afternoon before the experiment was begun. Weights on the following morning were 200 to 260 grams. To make the amount infused comparable to that given to the starved group, the actual body weight was considered to be 75 per cent of a theoretical initial weight. This theoretical weight was then calculated $\left(\frac{\text{actual weight}}{75} \times 100\right)$ and the "difference in weight" was used to compute the amount of whole blood to be infused. An amount of whole blood equal in milliliters to 5 per cent of this "difference in weight" was infused. Determinations of total blood volume, plasma volume, and red cell mass were performed on groups of 6 to 8 animals at infusion time (uninfused, fed control) and at 4, 24, and 48 hours after infusion.

Experiment 2. Chronic Undernutrition.—

Chronic undernutrition with whole blood infusion: Thirty-two rats weighing 350 to 410 grams, each individually housed in an air-conditioned laboratory,

were given such decreasing amounts of Purina laboratory chow that over a period of 42 days they lost weight to an average level of 78.7 per cent of initial body weight. At 7:00 A.M. on the day of infusion food was withdrawn, but water allowed ad libitum.

The total group was then divided into 4 subgroups of 8 rats each. The difference between initial weight and actual weight was calculated. In 3 groups an amount of whole blood equal in milliliters to 5 per cent of the difference in weight was infused beginning at noon. Determinations of volume components were performed on uninfused controls and at the usual time intervals after infusion in the other groups.

Fed control with whole blood infusion: Food was withdrawn at 7:00 A.M. on the day of the experiment. Water was allowed ad libitum. Weights at noon ranged from 290 to 350 grams. With these weights considered to be 80 per cent of a theoretical initial body weight, this theoretical weight was calculated $\left(\frac{\text{weight}}{80} \times 100 \right)$. The difference between the calculated initial body weight and actual weight was used to compute the amount of whole blood to be infused. This was done to make the amount comparable to that given the undernourished group. An amount of whole blood equal in milliliters to 5 per cent of the "difference in weight" was infused, and determinations of volume components were performed on uninfused controls and in the usual way in the infused groups.

RESULTS

Acute Starvation and Infusion.—As has been observed previously, total blood volume is reduced proportionately as weight is lost. Thus, there was little change in the figure for total volume when calculated as milliliters per 100 grams of actual weight.

Plasma volume showed a decrease from 2.6 ± 0.10 to 2.0 ± 0.35. This decrease in plasma volume reflected an increase in red cell volume from 2.3 ± 0.12 to 3.1 ± 0.16.

With this sequence as a control, the variation from it produced by the infusion of whole blood is apparent in Fig. 1. The elevation in total volume produced by infusion seemed to decline slightly over the 48-hour period of observation. This decline was at the expense of plasma volume which decreased correspondingly. Based on preinfusion values, the difference in the magnitude and duration of effect was slight between starved and fed groups after infusion.

With average values from the appropriate controls as preinfusion values, the estimated final blood volume for each rat was calculated by addition of the volume of infused blood to the average preinfusion control volume. The same was done for red cell and plasma volumes. This calculated average for expected final volume was then compared to the value actually measured for each group (Fig. 2). It can be seen that, except for the single point which compares estimated to measured plasma volume at 48 hours, there is close agreement in values between the 2 groups. Red cell volume was approximately 90 per cent

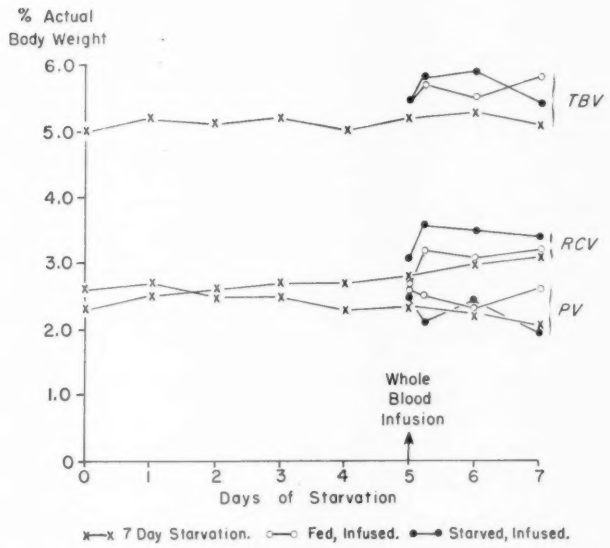

Fig. 1.—Blood volume response after transfusion compared with that of starved controls.

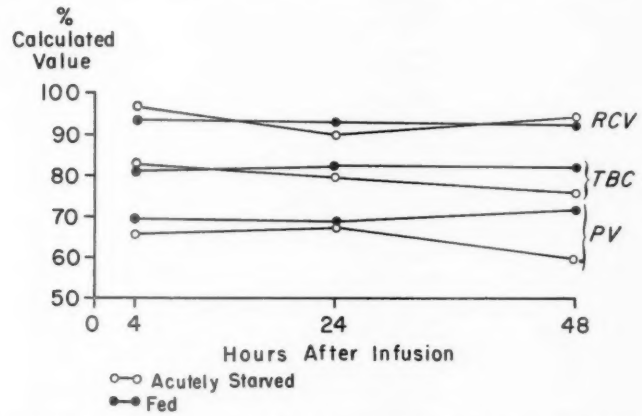

Fig. 2.—Comparison between measured and calculated values for blood volume components after transfusion in starved and fed rats.

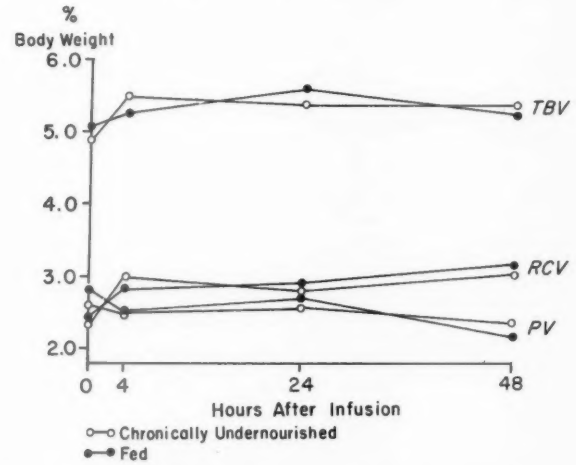

Fig. 3.—Blood volume response after transfusion in chronically undernourished and in fed rats.

of calculated volume throughout the period of observation. Total blood volume was about 80 per cent and plasma volume from 60 to 70 per cent of its calculated volume.

Chronic Undernutrition and Infusion.—Essentially the same sequence was observed in these groups as in the acutely starved animals. There was no difference in response between the undernourished rats and their fed controls (Fig. 3).

Expected values after infusion were calculated for both groups in the manner previously described, and were compared with the measured value for each group (Fig. 4). It can be seen that although there were minor variations between undernourished and fed groups, the order of magnitude of change was the same for both groups for each component of the blood volume. The comparison between the 2 groups of fed controls may be assumed to reflect the degree of variation inherent in the experimental method.

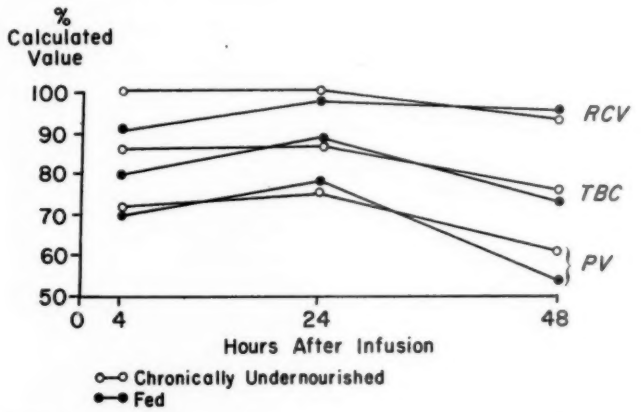

Fig. 4.—Comparison between measured and calculated values for blood volume components after transfusion in chronically undernourished and in fed rats.

DISCUSSION

These experiments demonstrate that acutely starved and chronically undernourished rats respond to equivalent amounts of infused blood in the same manner as normal animals. Infused red cells seemed to be maintained within the donor circulation during the 48-hour period of observation. More than 90 per cent of the expected increase in red cell volume was actually found in these determinations. Of the infused plasma, however, only 60 to 70 per cent of the administered amount was found at the time of the earliest determination (4 hours after infusion).

These findings do not answer the question of whether or not acutely starved or undernourished animals might be benefited by the administration of blood prior to trauma. They do demonstrate, however, that neither of the experimental groups had any special affinity for the infused blood.

This information and the previous findings from this laboratory show that any special deleterious effect on the blood volume is not likely to be

produced by weight loss. The blood volume of the undernourished or starved animal seems to be as adequate for it as the blood volume of a normal animal of the same weight.

SUMMARY

Infusions of whole blood were given to animals acutely starved and chronically undernourished to 73 to 79 per cent of initial body weight. Equivalent amounts of blood were given to normally fed controls whose transfusion weights corresponded to the transfusion weights of the animals in the experimental groups. No differences were demonstrated between the groups with respect to cell and volume changes subsequent to infusion.

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TIMING OF NERVE SUTURE AFTER A GUNSHOT WOUND

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WHEN is the best time to suture a peripheral nerve severed by a high-velocity missile? The experience of World War II, summarized in the reports of the Veterans Administration[5] and the Medical Research Council of Great Britain,[3] shows unequivocally that the suturing should not be carried out at the time of the initial débridement of the wound. At this operation, if the ends of the transected nerve are seen, the wisest course is to approximate the separated ends or to anchor them to neighboring tissue so that they will not retract further. For such procedures it is best to use a transfixing suture of fine stainless steel or tantalum. These materials will cause a minimal amount of tissue reaction and will mark the ends of the nerve at subsequent x-ray studies. They can be readily palpated by the surgeon who performs the later definitive suture.

Often in the débridement of a deeply penetrating missile tract the injured nerve will not be visualized because of the wide retraction of the severed ends. It is then inadvisable to extend an incision into healthy tissue, for it opens up fresh muscle planes for the spread of infection if the débridement is not followed by primary healing. When the injured nerve is not exposed, there is no way of telling whether it has been actually severed, partially transected, or merely contused. In the latter situation there may be a satisfactory spontaneous recovery. Return of function will be rapid if the axons are only mildly contused and do not undergo wallerian degeneration, a condition classified as neuronapraxia by Seddon.[4] However, if the severity of the compression has been sufficient to cause fiber degeneration without disruption of anatomic continuity, axon regrowth will start after a latent period of 10 days and will proceed distally at a rate of 1 to 3 mm. per day along the course of the empty but intact sheaths of Schwann (axonotmesis[4]). In this event, recovery of function may ultimately be nearly perfect, unless the nerve trunk becomes constricted by scar tissue at the point of injury.[1] Regeneration of axons can be followed by the advance of Tinel's paresthesia and by progressive recovery of muscles as the regenerating axons reach their motor end plates. The expected course of motor regeneration along intact sheaths of Schwann can easily be predicted by reference to diagrams which illustrate the levels of origin of muscular rami from the parent nerve trunks. These diagrams can be found in the monograph by Haymaker and Woodhall.[1] Experience in World War II, summarized in the Veterans Administration monograph on peripheral nerve

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regeneration,[5] has demonstrated that potentiality for recovery is not lost when the date of exploratory operation and suture is deferred up to 6 or even 9 months. Such long periods of observation are needed only when the sciatic nerve is injured just below the origin of the motor rami to the hamstring muscles and fibers must regenerate at least 45 cm. to reach the gastronemius or upper peroneal muscles.

Evidence that the nerve has been transected is often apparent at the primary débridement, and the surgeon is tempted to carry out the suture immediately. But the experience gathered by military surgeons in World War II and the Korean conflict in cases of high-velocity projectile wounds has demonstrated beyond any doubt that neurorrhaphy should be deferred for at least 1 month for 2 reasons. First, when a high-velocity missile passes through tissue, even if no bone is shattered, there is widespread contusion of tissue caused by the explosive wave of pressure.[2] As a result, the epineurium at each severed end of the nerve is softened so that sutures tend to tear out. Second,

Fig. 1.—Photograph of a median nerve exposed 3 months after its transection by a high-velocity rifle bullet. The proximal portion of the nerve lies to the right between the retracted portions of the pronator radii teres muscle. The end bulbs (distal glioma to left and proximal neuroma to right), separated by 3 cm. of scar tissue, are elevated on the rubber tissue slings.

and even more important, one can never tell to what extent proximal and distal scarring will subsequently develop. Such scarring could seal off the Schwann sheaths and form an impenetrable barrier against regeneration. This is illustrated by Fig. 1, which shows the extensive proximal neuroma and distal glioma which were found on the retracted ends of the median nerve at exploratory operation 3 months after the patient had sustained a gunshot wound of the soft tissue. Had a primary suture been performed at the time of wound débridement, it would have resulted in a dense neuroma-in-continuity at least 5 cm. in length. In addition, separation of the ends of the nerve, sutured under tension in the presence of softened epineurium, would have been highly probable, especially if there had been any infection after operation.

The following case report from civilian practice clearly illustrates the objections to early nerve suture after a gunshot wound.

CASE REPORT

C. M., a 49-year-old businessman, was cleaning a 32-caliber rifle loaded with a soft-nosed bullet when it discharged at 6-inch range. The bullet went through the lower portion of the axilla. It passed transversely and medial to the humerus, entering the lower attachment of the pectoralis muscle and exiting near the insertion of the latissimus dorsi in the lower part of the posterior axillary fold. On admission to the local hospital the patient had severe arterial bleeding, in addition to complete paralysis of the median and ulnar nerves. The surgeon who performed the operation found a nick in the lowermost portion of the axillary artery, which he was able to close. There was no injury to the vein, but the contiguous median nerve was transected. An end-to-end suture was carried out with fine silk stitches. No note was made concerning injury to the ulnar nerve. Blood loss necessitated 5 transfusions.

Three months later the man entered the Baker Memorial Hospital as a patient of Drs. C. Miller Fisher and H. Thomas Ballantine. The transverse axillary incision had healed uneventfully and the radial pulse was preserved, but there was no evidence of recovery of median or ulnar nerves in either motor, sensory, or sympathetic components. There was no Tinel paresthesia shown by percussion over the course of these nerves to indicate regeneration of any sensory fibers. In addition, there was moderate weakness of the motor and sensory distribution of the musculocutaneous and radial nerves. Electrical examination performed by Dr. Arthur L. Watkins revealed that the 2 latter nerves were intact, but paralysis of all the volar hand and forearm muscles was complete except in the brachioradialis (radial nerve).

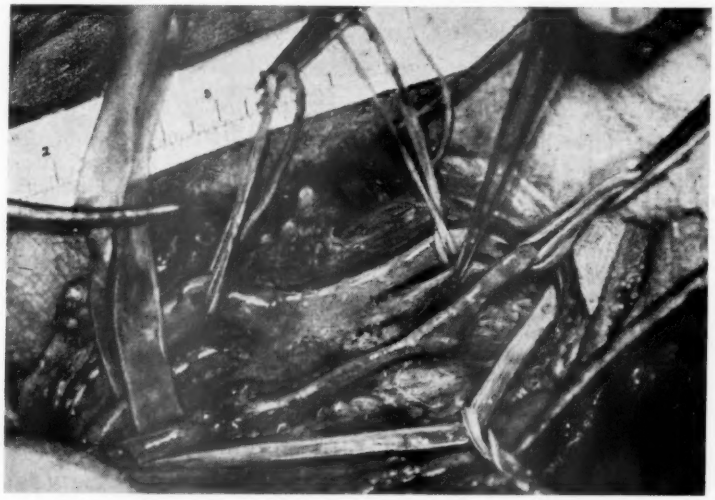
As a neurosurgical consultant I was asked whether or not a further period of observation should be recommended to allow for possible median and ulnar nerve recovery. A period of 92 days had already elapsed. The motor end plates in the first muscles that might be expected to recover (pronator radii teres supplied by the median nerve, and flexor carpi ulnaris supplied by the ulnar nerve) lay approximately 30 cm. below the level of the lesion. With allowance for a latent period of 10 days for recovery from transitory retrograde damage to the motor cells in the ventral horn of the spinal cord, and with an estimated 2 mm. daily growth of motor axons, regeneration should only have progressed 16 cm. Recovery of proximal muscles could not be expected to become apparent for another 2½ months. Because of the absence of any descent of Tinel's sign, and suspecting a neuroma-in-continuity of the median nerve and probably of the ulnar nerve as well, I advocated exploratory operation without further delay.

The operation was carried out on Nov. 10, 1959, with the assistance of Dr. Hermes Grillo who performed any necessary arterial repairs. Incision was made under local infiltration of the skin and subcutaneous tissues, which permitted sensory and motor stimulation of the nerves proximal and distal to the passage of the bullet. The incision was made along the course of the neurovascular bundle from the apex of the axilla two-thirds of the distance down to the antecubital space. Dense adhesions over 1.5 cm. in length were found between the artery and the median nerve. Also, one could distinctly make out the outline of a proximal neuroma and distal glioma connected by a broad isthmus of scar tissue which contained the silk stitches of the previous suture (Fig. 2). It was possible to evoke pain by electrical stimulation of the median nerve at a point 1 cm. above the neuroma, but no sensory impulses came through from below even with 20-volt stimulation, nor could any motor response be obtained. The ulnar nerve showed only a small shotlike hardening of its substance, past which saline solution injected beneath the epineurium flowed without difficulty. We concluded that there was a good chance that the ulnar nerve would still regenerate, but that the dense end bulbs of the median, together with the intervening scar, must be resected.

The 15 mm. length of fibrous tissue fusing the median nerve to the axillary artery proved to be so dense that a small leak developed while I was trying to resect the scar. This was closed by Dr. Grillo with a few sutures of arterial silk, and a portion of the adherent neuroma was left attached to the side of the artery. It was then necessary to

cut back each end of the nerve an additional 7 to 8 mm. (by means of serial proximal and distal slices made with a razor blade) before normal fascicles of nerve suitable for suture were seen. Thus the full extent of the excised scar measured 3 cm. in length and there was no microscopic appearance of axon penetration in the central two-thirds. After wide neurolysis and 90-degree flexion at the elbow it was easy to carry out an epineurial suture with interrupted stitches of arterial silk and marker sutures of tantalum wire placed 5 mm. on each side of the line of suture. The marker sutures should be inserted routinely to permit subsequent roentgenographic verification that the ends of the nerve remain in contact.

Convalescence was uneventful, the posterior plaster shell used to maintain flexion of the elbow at 90 degrees was removed after 3 weeks and full arm extension was encouraged



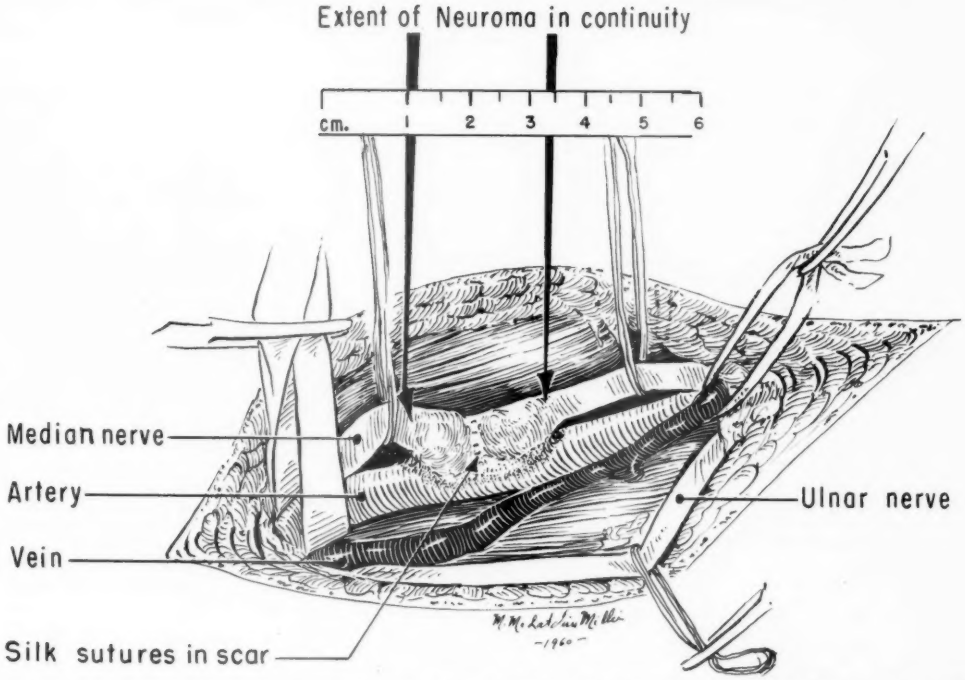


Fig. 2.—Appearance of median and ulnar nerves of the patient described in the text. *A*, Photograph taken at operation (slightly retouched). *B*, Diagrammatic drawing which illustrates the appearance of the structures described in the text.

after 1 month. Histologic examination showed the typical proximal neuroma with sprouting axon tips and Schwann sheaths becoming enmeshed in a dense central barrier of scar tissue. The smaller distal glioma contained only proliferating Schwann sheaths, with empty tubules below in which all myelin and central axons had degenerated long before.

One month after excision of the neuroma and suture a well-defined Tinel paresthesia was demonstrated by tapping. It extended several centimeters along the median nerve. At 4 months it extended downward nearly to the elbow. In the case of the mildly contused ulnar nerve, the Tinel sign by this time had reached the wrist and sensibility was already returning to the hypothenar eminence.

DISCUSSION

This case has been presented in detail because it illustrates so clearly the futility of attempting early suture of a nerve that has been severed and subjected to the explosive contusion of a high-velocity missile. At best, if the sutures do not tear out of the softened epineurium, the procedure is likely to result in a neuroma-in-continuity, with a dense zone of scar tissue offering an impenetrable barrier to the downward growth of regenerating nerve fibers. The surgeon is obliged to wait a number of months before he can be sure that any regeneration is taking place, and many months will have to elapse before he can be sure of a satisfactory result. It is therefore obvious that it is best to limit the initial operation to cleansing and débridement of traumatized tissue, with necessary repair of injured blood vessels, tendons, or bone. Give the edematous, partially necrotic nerve ends time to resolve. Experience has taught that within 1 month the epineurium will become firm and will hold sutures well, and the extent of cicatrix that must be cut back to uncover healthy new fascicles will be clearly defined. The 1-month delay may save a year, or even more, and the chances of effective regeneration will be greatly increased.

SUMMARY

Differences of opinion exist regarding the desirability of early nerve suture at the time of débridement after a relatively clean incised wound. While many British surgeons disagree, the majority of Americans recommend this course and their statistics appear to justify the resultant saving of time. When a nerve is severed by a high velocity projectile, however, all neurosurgeons trained in the recent wars agree that suture should be deferred to a second stage to be performed at least 1 month after the primary débridement. This delay is mandatory, for a well-executed nerve repair immediately after injury by gunshot is not possible. The softened epineurium cannot be counted on to hold sutures, and there is no way of telling how much to trim off the injured stumps. Adequate proximal and distal neurolysis to insure a suture free of tension is not justified, because it exposes healthy tissue planes to the risk of spreading infection. The suture is therefore threatened by the risk of separation and, if it holds, by an endoneural barrier of scar tissue.

A typical gunshot injury is described which illustrates the cause of failure of early nerve repair. The only result of suturing the blast-softened, semi-necrotic ends of the divided median nerve was the development of neuroma-in-continuity. No regenerating axons could have penetrated the 3 cm. barrier of

scar, which had to be excised and resutured after 3 months had been wasted. Attempts at primary suture under such conditions can delay recovery many months before failure of regeneration becomes a certainty and forces the surgeon to resect the neuroma and resuture the nerve.

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SURGICAL IRRIGATION APPARATUS

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MOST methods of cleansing and irrigating grossly contaminated surface wounds are inefficiently slow, cumbersome, messy, and uneconomical. This is particularly true in the treatment of burn injuries. As a rule, wound cleansing is carried out on the operating table with either a bulb syringe or an elevated sterile container with an attached rubber hose. The circulating nurse is kept active obtaining sterile sheets and towels and bottles of autoclaved irrigation solution. The irrigation solution is applied by the surgeon as a "squirt" of water which is difficult to maintain at an optimal temperature. Eventually the surgical drapes, the floor, and the surgeon himself become soaking wet. The patient, lying on sheets puddled with contaminated irrigation solution, has to be turned and lifted in order to be placed on dry sterile sheets before dressings are applied. Even after all the effort and expense of these methods, the result is often an inadequate cleansing. Needless to say, such methods are not desirable. At best they accomplish only dilution and distribution of the contamination. They require the lifting and turning of a sick patient and also require more time, sterile material, and personnel than necessary.

An apparatus has been devised and economically installed in one of the operating rooms at the University of Mississippi Hospital as a simple and practical approach to the improvement of the technique of cleansing contaminated surface wounds. It consists of a large old-fashioned bathtub mounted securely on the chassis of a stainless-steel hospital stretcher which has conductive wheels. The tub is inclined slightly from head to foot to facilitate drainage. A litter frame made of aluminum tubing was designed to rest on the tub. The frame level recesses to 2 inches below the upper rim of the tub. The tub and frame are cleansed with an antiseptic solution prior to use. Sterile stainless-steel clip bands (1.5 feet long and 0.5 to 1.0 foot wide) fasten onto the frame for support of the patient (Fig. 1).

Tap water* in abundant amounts is used for irrigation. The force of the water is regulated through a mixing faucet on the wall at elbow level. A thermometer is attached to the faucet for accurate determination of the desired temperature. The water from the mixing faucet is conducted through the housing of a retracting hose high on the wall (Fig. 2). The required length of unsterile hose from the housing is held at the tub by the circulating nurse while it is attached to an autoclaved all-metal section of hose 3 feet in length which is held by the surgeon. A metal spray nozzle on the hose forms either a flush

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*Repeated cultures have failed to reveal pathogenic bacteria in the tap water.

Fig. 1.

Fig. 2.

Fig. 1.—A litter frame made of aluminum tubing rests on the tub. The frame level recesses to 2 inches below the upper rim of the tub. The tub and frame are cleansed with an antiseptic solution prior to use. Autoclaved stainless-steel clip bands fasten onto the frame for support of the patient.

Fig. 2.—A mixing faucet is on the wall at elbow level. A thermometer is attached for direct temperature reading. The housing of the retracting hose is high on the wall.

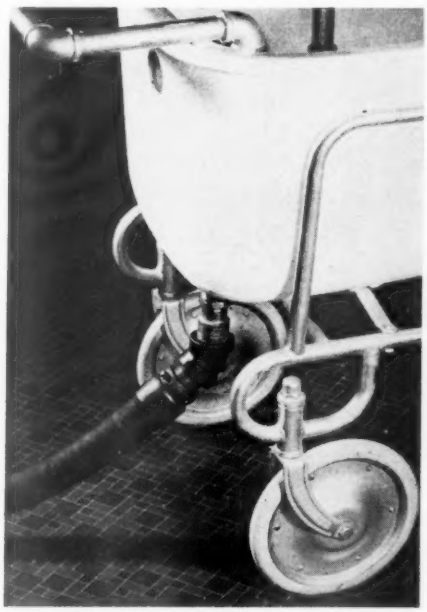

Fig. 3.—The water drains readily through a large rubber hose connection. The tub is mounted on the chassis of a stretcher with conductive wheels.

spray or a fine needle spray for irrigation. All water drips into the tub and drains out readily through a large rubber hose connected directly to a water trap outlet (Figs. 3 and 4).

The frame will accommodate a large adult as well as a small child. After the metal bands have been spaced to make circumferential areas of the body accessible, the patient (Fig. 5) is placed directly on the bands (Fig. 6). If the patient must be supported by portions of the body which contain wounds,

Fig. 4.—A drain hose connects the tub directly to a water trap outlet.

Fig. 5.—Except for the initial layer, the burn dressing is removed from the patient in the hospital bed.

the bands may be padded with a folded sterile sheet for comfort and to prevent further trauma. After attaching the 3-foot section of autoclaved metal hose (Fig. 7), gowned and gloved physicians begin the cleansing procedure. The entire body can be "scrubbed" with sterile gauze pads and a bland liquid soap containing Hexachlorophene, then thoroughly rinsed (Figs. 8 and 9). In essence, a shower bath is given to a patient in the reclining position. All water drains into the tub and out through a hose to a water trap outlet. Dressings are applied while the patient rests on the frame (Fig. 10).

At the end of the procedure, the patient has been safely and thoroughly cleansed with greater facility and at less expense than is possible with other

Fig. 6.

Fig. 7.

Fig. 6.—The patient is placed directly on the sterile steel bands which support him in a way which allows circumferential areas to be exposed.

Fig. 7.—At the tub, the unsterile hose is held by the circulating nurse while it is attached to an autoclaved all-metal section of hose 3 feet in length.

Fig. 8.

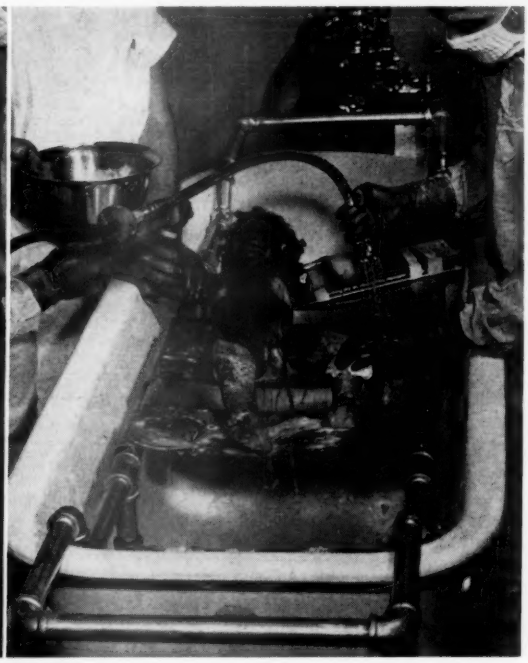

Fig. 9.

Fig. 8.—A metal spray nozzle forms a gentle flush spray for soaking and removing the initial gauze layer. The water drips into the tub.

Fig. 9.—A gowned and gloved physician cleanses the wounds gently with soft sterile gauze pads and a bland liquid soap containing Hexachlorophene. Thorough drinsing follows.

methods (Fig. 11). The surgeon is dry, not soaked, and is not standing in a puddle of contaminated water which could be tracked around the surgery suite.

Usually only analgesia is required for a routine change of burn dressing. If desired, general anesthesia and operation can be performed without moving the patient from the frame.

Fig. 10.—Dressings are applied while the patient rests on the frame. At the end of the procedure, the surgeon is dry.

Fig. 11.—After the cleansing and dressing, the patient is placed directly in bed for return to his room.

SUMMARY

Most methods of cleansing and irrigating grossly contaminated wounds are inefficient. A practical apparatus for surgical irrigation has been devised and is described. Such an apparatus can be economically installed and would be advantageous in any hospital where a large number of soft tissue wounds (particularly burns) are treated.

Pediatric Surgery

CONDUCTED BY MARK M. RAVITCH, M.D.

PEDIATRIC SURGERY IN A LARGE GENERAL HOSPITAL

A 5-YEAR SURVEY

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THE purpose of this report is to classify and review briefly the cases of 1,799 general surgery patients under the age of 12 years who were treated on the Louisiana State University Pediatric Surgery Service of the Charity Hospital of Louisiana at New Orleans from Aug. 1, 1954, through June 30, 1959. This report documents the nature of the clinical material and the attitudes toward therapy on a large public ward service.

During the period covered by this report, children constituted 33 per cent of the total number of patients admitted. This series accounted for 1.5 per cent of all the children admitted. The higher percentage of males than females on the Pediatric Surgery Service was due to the large number of boys admitted with trauma and with inguinal hernia.

GENERAL POLICY

In the Charity Hospital at New Orleans, a 3,063-bed general hospital, there are three services, Independent, Tulane, and Louisiana State University (L.S.U.). The last two are associated with schools of medicine. Specific rules govern admission to the various departments. All patients with chest conditions, except tracheoesophageal fistula and its complications, are assigned to Thoracic Surgery. Burn patients are sent to Plastic Surgery, those with fractures and osteomyelitis are treated by Orthopedics, and patients with head injury are admitted to Neurosurgery. Abdominal trauma in patients with multiple injuries is treated by Surgery. Such patients are included in this report.

All patients under the age of 12 years, and none over this age, are admitted to one floor of the hospital. Contagious diseases are treated in another building. There are separate wards for medical, surgical, and surgical specialty patients. Most pediatric surgery patients are admitted to surgical wards, but a few, particularly newborn infants, are either treated on Pediatrics or are transferred to Surgery after operation.

With few exceptions, neither age nor size of the patient is allowed to influence indication for operation. It is the policy of the L.S.U. Pediatric Surgery Service to postpone elective operation only in the event of (1) age less

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than 2 weeks, (2) weight less than 4½ pounds, (3) respiratory or cutaneous infection, (4) systemic disease, (5) abnormalities incompatible with a reasonable life expectancy, and (6) anemia.

These are relative contraindications to be weighed against the possibility of malignancy (masses), the risk of infection (cysts and sinuses), and the threat of incarceration (hernias). To minimize cross infection, particularly of the respiratory tract, hospitalization is as brief as is compatible with sound surgical judgment. Most patients are admitted the day before and discharged the day after elective operation.

There are no rigid rules governing treatment or choice of incision. When possible, incisions are made in creases or wrinkles or at right angles to underlying muscle. Both transverse and vertical abdominal incisions are used, depending on the preference of the surgeon and the condition anticipated. McBurney incision is usually employed for appendectomy. Ninety-two per cent of the operative procedures were performed by general surgical residents. Most of the remainder, including many of those in the newborn patients, were carried out by one member of the full-time staff of the Department of Surgery of the L.S.U. School of Medicine.

Special pediatric surgery clinics were created in Charity Hospital in January, 1955, to facilitate careful study of diseases requiring operation in children. Follow-up of most postoperative patients is unsatisfactory, however, because of the difficulty in securing long-term attendance in clinics. For the sake of brevity, results are not included in each group of patients in this report, but all known unfavorable results are included.

ANESTHESIA

In Charity Hospital, anesthesia is administered by student nurse-anesthetists and resident anesthesiologists under the supervision of Dr. John Adriani, Professor of Pharmacology at Louisiana State University and Tulane University Schools of Medicine and Head of the Department of Anesthesia at Charity Hospital.

Preanesthetic medication, ideally given 1 hour before induction of anesthesia, consists of a drying agent (Bellafoline*) for all patients and a barbiturate (Seconal) for children over the age of 3 months. The drying agent is a necessity in all pediatric anesthesia, but the smaller the patient, the more important it is.

Before any anesthetic is administered, a small stethoscope is taped over the precordium to enable the anesthesiologist to monitor the heart sounds continuously in addition to his counting the peripheral pulse frequently during operation. Blood pressure is often difficult to obtain in small infants, but a blood-pressure cuff is always applied. Endotracheal tubes of the proper size are prepared, and sterile instruments, including scalpels, are in the operating room before anesthesia is started.

All anesthesia in pediatric surgery patients is given by closed system, usually with cyclopropane induction and maintenance on ether.

Indications for endotracheal anesthesia include (1) open chest operation, (2) any position of the patient except supine, (3) head and neck operation,

(4) upper abdominal operation, (5) intestinal obstruction, (6) prolonged operation, (7) difficulty in maintaining a satisfactory airway, and (8) difficulty in obtaining an airtight fit with a face mask. No postoperative complication in this series could be attributed to the use of an endotracheal tube.

Although infants have very poor cough and gag reflexes when awake, laryngeal and pharyngeal reflexes are extremely sensitive under anesthesia. Since stimulation during induction is likely to excite a severe laryngospasm, the patient is not disturbed in any way during this dangerous period. The threat of laryngospasm is so great that the proper dose of muscle relaxant, such as succinylcholine, is drawn up in a syringe before anesthesia is started. Should laryngospasm occur, the relaxant is given before anoxic bradycardia develops. Laryngospasm is as frequent during emergence from anesthesia as during induction, and therefore the scrub nurse remains in the operating room with uncontaminated instruments until the patient has reacted.

In pediatric anesthesia, the surgeon should stand at the operating table during induction of and emergence from anesthesia. In the event of serious difficulty, the surgeon might well assume the responsibility of listening to the heart tones, allowing the anesthesiologist to devote his entire attention to the problem of the airway. Thus the surgeon is immediately aware of the possibility of cardiac arrest and, if necessary, can enter the chest without delay. Infants have a high rate of metabolism and a low oxygen reserve, and anoxia develops rapidly with respiratory obstruction. In addition, the heart will often stop before the laryngospasm relaxes.

The tidal exchange may be so small and the respiratory effort so weak in a tiny infant that assisted respiration may be necessary to assure adequate ventilation. Under no circumstances should heavy drapes, instruments, or the hand of an assistant be allowed to rest on the chest of an infant.

Four of the 5 cardiac arrests in this series were directly attributable to anoxia. Three occurred as a result of laryngospasm during the induction of or emergence from anesthesia, and one occurred during operation because of difficulty in maintaining an adequate airway. In each case, the chest was opened promptly and the heart massaged. Recovery was immediate and complete. The fifth cardiac arrest, possibly due to a vagal reflex, occurred the instant an endotracheal tube was inserted. By the time the chest was opened, the heart had resumed normal action.

The one death in which anesthesia might be incriminated occurred in a 7-month-old infant during partial right hepatic lobectomy for hepatoma. At autopsy only the middle lobe of the right lung was found to contain air. The remainder of both lungs was completely collapsed. Respiration had not been assisted during operation, and it is possible that insufficient ventilation had resulted in atelectasis.

TOTAL PATIENTS

In this series of 1,799 patients there were 59 deaths, a mortality rate of 3.2 per cent (Fig. 1). Autopsy was performed on 48 (81 per cent). Deaths were

*Sandoz Pharmaceuticals Division, Sandoz Chemical Works, Inc., Hanover, N. J.

included only if they occurred in the hospital while the patient was under the care of the L.S.U. Pediatric Surgery Service. All other known deaths are noted.

The sums of the individual groups of patients are greater than the totals listed, because some patients are included under two diagnoses.

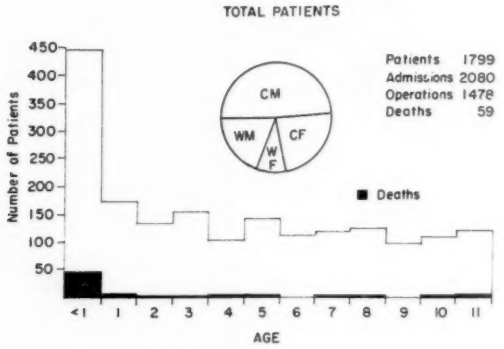

Fig. 1.

GROUP I. INGUINAL HERNIA, HYDROCELE, UNDESCENDED TESTIS

Five hundred thirteen patients were admitted with inguinal hernia, hydrocele, and undescended testis (Fig. 2). Forty-two per cent of the hernias were on the right side, 41 per cent on the left, and 17 per cent were bilateral.

Four hundred sixty-four operations were performed on 450 patients. Operation consisted of high ligation of the sac without removal of the entire sac if it was a long one. In the occasional cases of very large indirect hernia or direct hernia, a modified Bassini repair was carried out. One recurrent hernia was repaired after hernioplasty had been performed elsewhere.

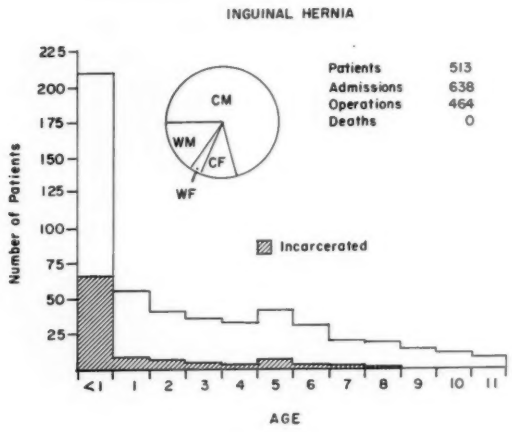

Fig. 2.

Two hundred thirty-two patients underwent bilateral inguinal exploratory operations. Fifteen had the two sides repaired separately, either because only unilateral hernia was diagnosed originally, or because the repair of the first side was complicated or time-consuming. In the case of history of only unilateral hernia, decision to explore the opposite side was based on physical findings.

In infants under 1 year of age, in females, and in patients with hernias on the left side, the other side was usually explored. Twenty-one patients had a negative exploration of the opposite side, 10 on the right and 11 on the left. The records do not show how many unsuspected hernias on the second side were found.

Sixty-seven patients had hydroceles, all associated with hernias except one (and the diagnosis is questioned in this case). A hydrocele in a child, with the possible exception of a "physiologic" hydrocele in a newborn infant, was assumed to indicate the presence of an indirect inguinal hernia. Operation consisted of dividing and ligating the proximal end of the hernia sac and opening, but not excising or bottling the hydrocele. An inguinal hernia was repaired in one child after a scrotal operation had been performed for hydrocele in another hospital.

Of the 26 patients with undescended testis, only one had no associated hernia. In these patients, the hernia sac was freed and ligated and the vas and vessels dissected retroperitoneally. A suture through the lower pole of the testis was brought out through the bottom of the scrotum and tied to a rubber band which was taped to the thigh for 6 or 7 days.

Forty per cent of the patients with hernias and 64 per cent of those with incarcerated hernias were less than 1 year of age. Early operation was advised for all patients with inguinal hernias because of the increased incidence of incarceration in infants. Incarcerated hernias without evidence of strangulation were treated with sedation, scrotal ice bag, and elevation of the buttocks for 2 or 3 hours. Eighty patients were admitted with incarcerated hernias. In 61 the hernia reduced and was later repaired electively. Of the 19 subjected to emergency operation, only one, with a Richter's hernia, had gangrenous bowel. Two patients had infarcted testes and 3 had acute hydroceles with edema of the spermatic cord and inguinal area. Abdominal exploration was required in 4 patients for inspection of an incarcerated bowel that reduced before the hernia sac was opened.

Twenty-two of the total hernia patients had sliding hernias, containing colon (2), bladder (5), and uterus, tube, and/or ovary (15). Seven infants had direct inguinal hernias, usually in combination with indirect.

The only death in a hernia patient occurred in a 3-month-old baby who had an emergency operation for incarcerated hernia and died at home 13 days later. The complications of inguinal hernioplasty are given in Table I.

TABLE I

COMPLICATION	ELECTIVE	EMERGENCY
Cardiac arrest	1	1
Wound infection	3	—
Hematoma	12	1
Aspiration pneumonitis	6	—
Bronchiolitis	1	—
Atrophy, testis	3	4
Recurrence	2	1

GROUP II. INFECTIONS

Of the 254 patients admitted with an infection or foreign body, 9 died (Fig. 3). One hundred ninety-eight operations were performed, usually simple incision and drainage of a superficial abscess. Types of infection are shown in Table II.

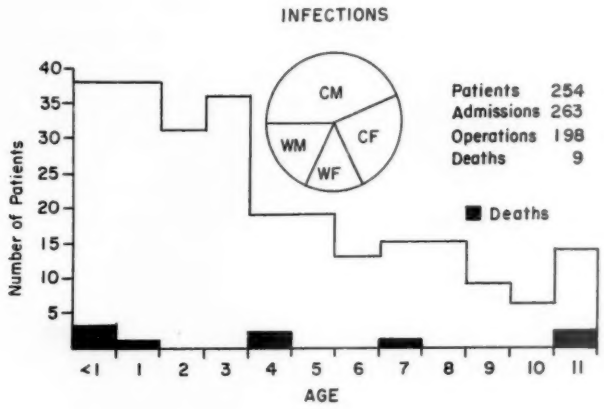

Fig. 3.

TABLE II

INFECTION	NO.	DEATHS
Lymphadenitis, usually suppurative	79	–
Cervical	38	–
Inguinal	25	–
Axillary	8	–
Epitrochlear	3	–
Iliac	3	–
Preauricular	2	–
Posttraumatic infection, 10 tetanus	93	6
Subcutaneous abscess	49	–
Perirectal abscess	7	–
Perineal abscess	1	1
Breast abscess	7	–
Sepsis and ileus	4	2
Primary peritonitis	4	–
Osteomyelitis	3	–
Intra-abdominal abscess	2	–
Liver abscess	2	–
Perinephric abscess	1	–
Psoas abscess	1	–
Thyroiditis	1	–

Tetanus was the cause of death in 5 patients and was suspected in another patient who died with extensive cellulitis of the leg. A 14-month-old boy died after colostomy and drainage of an extensive infection of the lower abdominal wall, scrotum, perineum, and buttocks. Two deaths occurred in the 4 newborns who underwent exploratory operations for intestinal obstruction but who were found to have paralytic ileus due to sepsis. One of the 2 who survived underwent two subsequent laparotomies for obstruction due to adhesions and the other had multiple abscesses, pyarthrosis, and osteomyelitis.

The breast abscesses were all in patients less than 1 month of age. One abscess extended from the anterior midline to the posterior axillary fold and

from the clavicle to the crest of the ileum. An infant with primary peritonitis developed postoperative abscesses in bilateral hydroceles which permanently disappeared after purulent exudate was aspirated. One intra-abdominal abscess occurred between the liver and the anterior abdominal wall. The other was apparently due to spontaneous perforation of the jejunum.

Multiple liver abscesses occurred in the left lobe in a 9-year-old boy and in the right lobe in a 2-year-old girl with visceral larva migrans. An 8-year-old boy had tracheal obstruction due to a huge retropharyngeal abscess which occurred after a BB-shot wound of the neck. He later developed an esophageal fistula which closed spontaneously. Thyroiditis secondary to an adjacent suppurative lymph node occurred in a 2-year-old boy.

GROUP III. APPENDICITIS AND ITS COMPLICATIONS

Two hundred twenty-two patients were treated for appendicitis and its complications (Fig. 4). A correct preoperative diagnosis was made in 82 per cent of the 213 patients who underwent exploratory operation for appendicitis. Of the 174 patients with appendicitis, 75 (43 per cent) were found to have perforated appendix at operation. One patient was reported to have "chronic appendicitis."

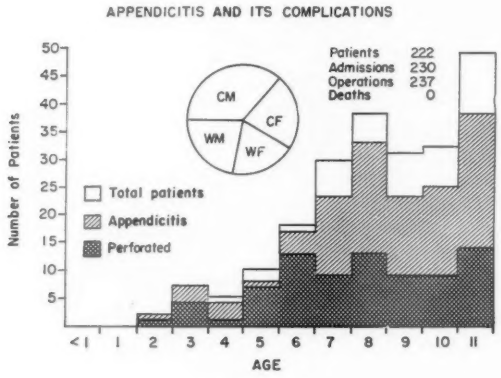

Fig. 4.

Duration of symptoms varied from a few hours to 12 days. One child had a gangrenous appendix after an illness of 10 hours and another had a perforated appendix 15 hours after onset of symptoms.

Five patients underwent interval appendectomy, 3 after simple drainage of an appendiceal abscess, 1 after a cul-de-sac inflammation due to appendicitis, and 1 for recurrent abdominal pain due to barium which had been retained in the appendix for 6 months. An additional patient later underwent interval appendectomy elsewhere after drainage of an appendiceal abscess on the L.S.U. service.

The complications of appendicitis (174 appendectomies for appendicitis) were wound infection (24), wound bleeding (5), wound hematoma (3), cul-de-sac abscess (4), retrocecal abscess (1), left lower quadrant inflammation (2), gastrointestinal bleeding (2), atelectasis (1), intestinal obstruction, adhesions (5, 1 gangrene ileum), and incisional hernia (1). There were no deaths.

GROUP IV. ABDOMINAL PAIN

Ninety-seven patients were admitted for possible acute appendicitis but no exploratory operation was performed because signs and symptoms had subsided during the long and time-consuming admitting procedure at Charity Hospital (Fig. 5). The causes of abdominal pain were gastroenteritis (11), dietary indiscretion (2), respiratory infection (8), urinary tract infection (2), ascariasis (4), fecal impaction (1), and unknown (69).

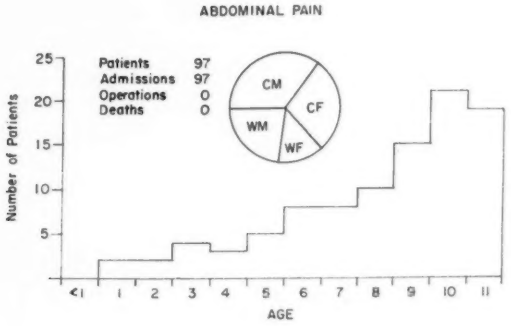

Fig. 5.

GROUP V. CONGENITAL ANOMALIES

Two hundred three patients were treated for congenital anomalies other than inguinal and umbilical hernias and 33 of these patients died (Fig. 6).

Gastrointestinal Anomalies.—Of the 110 patients with anomalies of the gastrointestinal tract, 31 died.

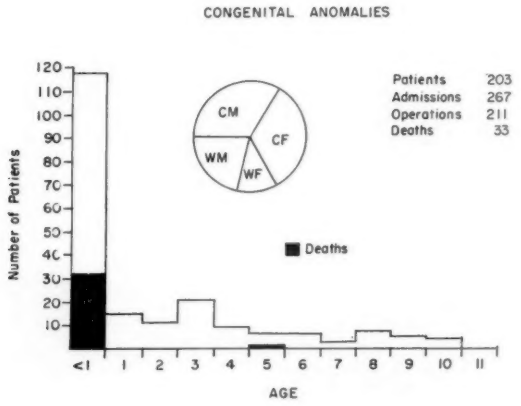

Fig. 6.

Pyloric stenosis: Twenty-five patients had congenital hypertrophic pyloric stenosis. All survived pyloromyotomy, including 2 in whom the duodenum was inadvertently opened and 4 who were premature infants still in the premature nursery. Postoperative complications included wound infection in 7 patients, generalized convulsions in 1, and incisional hernia in another.

Esophageal atresia and stenosis: Sixteen infants were treated for anomalies of the esophagus. Eight died. Fourteen patients had the most common type

of anomaly, the proximal esophagus ending as a blind pouch and the distal esophagus communicating with the trachea. One patient had atresia of the esophagus, without fistula, but with absence of the distal esophagus. Another had a simple stenosis misdiagnosed as atresia because the catheter had not been withdrawn when roentgenograms were made. The stenotic esophagus was obstructed by the tip of the catheter and contrast studies seemed to show atresia.

A transpleural approach was used for primary repair in 10 infants, 6 of whom died. There was 1 wound infection. Leak at the anastomosis occurred in 2 patients. One survived after gastrostomy and closed drainage of the chest but later developed a diverticulum at the site of the anastomosis. Three of the 4 surviving infants had been admitted with food impacted above the anastomosis but without roentgenographic or esophagoscopic evidence of a stricture.

Two moribund premature infants died without operation. Of the 10 full-term infants on whom exploratory operation was performed for esophageal lesions, 6 died with pneumonitis and atelectasis. Only 2 had no other anomaly. Four patients had originally undergone exploratory operation elsewhere or in Charity Hospital before 1954. Two were admitted for resection of an anastomotic stricture. One (with absence of the distal esophagus) came in for construction of a jejunal esophagus in the anterior mediastinum. The fourth had a "stricture" of the lower esophagus which was determined to be cardioesophageal junction.

Intestinal atresia and stenosis: Of the 16 patients with stenosis or atresia of the intestine, 9 died.

Duodenal obstruction occurred in 11, 5 of whom died. Of 3 patients who were mongoloid defectives, 2 survived. After duodenojejunostomy 1 patient developed a wound infection and another, aspiration pneumonitis. A third patient had anuria due to polycystic kidneys. All but 1 of those who died had extragastrointestinal tract anomalies. Six of the 9 patients with complete obstruction had malrotation and 1 also had a Meckel's diverticulum.

Nine patients had atresia of the duodenum. Four survived, 3 died after operation, and 2 died without operation. Two patients with stenosis of the duodenum survived. One underwent exploratory operation at 16 days of age, and the other, a mongoloid, at 6 years.

Jejunal atresia occurred in 4 patients, all of whom died. Three were premature infants and 1 full-term. The only other anomaly noted in these patients was absence of the small bowel mesentery with volvulus of the distal small bowel in 2 cases.

In cases of jejunal atresia, the site of obstruction was resected and a modified end-to-end 2-layer anastomosis was performed. One patient died of aspiration of vomitus and another of peritonitis after disruption of the anastomosis. The 2 with volvulus lived 4 weeks. One finally died of sclerema and malnutrition and the other of obstruction due to pneumatosis cystoides intestinalis.

Stenois of the ascending colon occurred in 1 full-term infant who survived right hemicolectomy at the age of 10 days.

Imperforate anus: Of the 9 patients with anal anomalies, only 1 died. Only 1 patient required operation as a newborn, a 12-day-old male who underwent a pull-through procedure for atresia of the rectum at the mucocutaneous junction. Three females had imperforate anus with fistula to the vagina, fossa navicularis, and perineum. Two infants had simple stenosis requiring only dilatation and 1 died of other anomalies.

Three patients were admitted after operation elsewhere. One, with a persistent rectourethral fistual and anal stenosis, required colostomy and suprapubic cystostomy before a pull-through could be accomplished.

Malrotation: Three patients were treated for malrotation. One died. (Malrotation was also seen in 6 patients with duodenal atresia, 5 with omphalocele, 1 with meconium ileus, and in 1 Siamese twin.)

Operation for malrotation was performed in 2 newborn infants. A full-term infant survived but a premature infant died after a second operation to relieve obstruction due to postoperative adhesions. A 3-year-old boy who had been treated prior to 1954 again underwent exploratory operation for persistent vomiting, but no adhesions were found.

Omphalocele: Thirteen patients were treated for omphalocele. Nine died. Six patients had small omphaloceles closed primarily. In 2 the sac contained only a Meckel's diverticulum, one of which was a giant diverticulum measuring 5 cm. Three of these 6 patients died, 1 of multiple anomalies, 1 of sclerema, and 1 after a second operation for obstruction due to malrotation.

Two patients had large omphaloceles. One died of sclerema after only skin closure, and the other died after premature secondary repair at the age of 2 months. One premature infant with a ruptured omphalocele had gangrene of the eviscerated bowel and died shortly after operation.

Two newborn infants were admitted after repair of an omphalocele had been carried out in a private hospital. Both died with multiple anomalies, including exstrophy of the bladder. Second stage repair of a large omphalocele was performed on a 1-year-old child originally operated upon elsewhere. A 5-year-old boy who had had a small omphalocele died shortly after admission for intestinal obstruction with gangrene of the colon.

Biliary atresia: Of the 8 patients with biliary atresia, 1 died. Six patients had atresia not amenable to correction. One patient had a tiny stenotic duct intubated but not anastomosed to the bowel. She subsequently became free of jaundice and began having bile in the stools. One of the 6 patients died of intestinal obstruction 4 months after operation. Another patient was admitted with obstruction after exploratory operation elsewhere.

Hirschsprung's disease: Eight children were treated for congenital megacolon. Of the 4 who underwent a pull-through operation, only 1 required preliminary colostomy. The only complication was cardiac arrest in 1 patient, successfully treated with cardiac massage. One patient moved out of the state without operation and 3 were admitted postoperatively.

Five patients, including 3 who had undergone a pull-through operation on the L. S. U. service and 2 others who were admitted after operation elsewhere, had episodes of severe abdominal distention due to gas and liquid feces. Vigorous decompression relieves such symptoms, but the condition has a tendency to recur.

Another postoperative patient, who had undergone a pull-through operation before 1954, had recurrent perineal and rectovaginal fistulas which eventually necessitated permanent sigmoid colostomy.

Meckel's diverticulum: The diverticulum was resected in 4 patients, 2 with hemorrhage (6 and 11 months old) and 2 with diverticulitis (4 and 6 years old). (Meckel's diverticulum was also seen in 2 patients with omphalocele, 1 with duodenal atresia, and in 1 Siamese twin.)

Duplication: This condition occurred in 2 patients, a 6-month-old boy with an intussusception due to an intramural duplication of the ileum, and an 8-month-old girl with intestinal obstruction due to adhesions of the omentum to a duplication of the ileum. The latter patient later had obstruction due to postoperative adhesions.

Meconium ileus: Two patients had meconium ileus. One died of multiple anomalies the day after operation and the other was admitted with a wound infection following closure of an ileostomy elsewhere.

Meconium constipation: Meconium constipation causing obstruction in a premature infant was successfully treated with enemas.

Chylous cyst: Chylous cyst of the jejunal mesentery caused obstruction in a 5-week-old infant who later developed obstruction due to adhesions.

Absence of the muscularis of the stomach: This condition resulted in perforation in a 5-day-old infant who died of peritonitis shortly after operation.

Diaphragmatic hernia: A hernia through the left pleuroperitoneal hiatus was found in a 2-year-old boy. A wandering spleen was removed when the hernia was repaired.

Congenital Cysts, Sinuses, and Fistulas.—These conditions occurred in 73 patients, all of whom survived.

Thyroglossal duct cyst: This cyst was seen in 12 patients. The cyst was in the upper pole of the left lobe of the thyroid in 1 child.

Branchial cleft anomalies: Such anomalies occurred in 29 patients. Thirteen anomalies were in the cervical area (3 cysts, 7 fistulas, 2 cysts with fistulas, and 1 skin tag containing cartilage), and 17 were preauricular (12 cysts with sinuses and 5 skin tags). Three of the 6 previously infected preauricular cysts recurred after operation.

Dermoid cysts: Regions in which dermoid cysts, found in 28 patients, were located included lateral eyebrow (8), suprasternal (5), postauricular (5), occipital (3), hyoid area (2), anterior fontanelle (1), preauricular (1), umbilical (1), lateral cervical (1), and forehead (1). The dermoid on the forehead involved the outer table of the skull, and the Neurosurgical Service later removed the remainder of the lesion.

Teratoma: In 1 patient teratoma occurred in the lateral cervical area between the 2 heads of the sternocleidomastoid mastoid, and in another it occurred in the ovary. Evisceration occurred after operation in the latter patient.

Pilonidal sinus: In 1 patient a pilonidal sinus was excised because of previous infection.

Sacral dermal sinus: A sacral dermal sinus was found in a 1-year-old infant who had suffered 2 previous episodes of meningitis. On a subsequent admission (elsewhere) for meningitis, the dermal sinus extending into the cord was excised.

Miscellaneous Congenital Anomalies.—Various anomalies were seen in 20 patients, 2 of whom died. The various conditions encountered were epigastric hernia (4, 1 incarcerated), multicystic kidney (3, 1 death), supranumerary digits (5), Siamese twins (2, 1 death), pseudohermaphrodism (1), hydrometrocolpos (1), perineal fissure (1), myelomeningocele (1), tongue-tie (1), and diastasis recti (1).

Two of the infants with multicystic kidney developed wound infection and evisceration occurred. One died of sepsis and the other developed a fecal fistula but survived. (Multicystic kidney was also seen in a patient with a large omphalocele.)

The patient with hydrometrocolpos developed an incisional hernia which was repaired 4 months later.

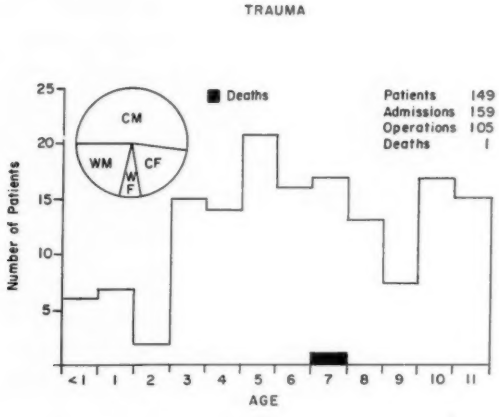

Fig. 7.

GROUP VI. TRAUMA

One hundred forty-nine patients were admitted after trauma (Fig. 7). There was only 1 death. (Patients with head injury are usually admitted to Neurosurgery and those with burns to Plastic Surgery. None of these patients are included.)

Extremities.—Eighty patients had injuries to the extremities, 50 involving tendon, nerve, or joint.

There were 3 gunshot wounds, including one in a 10-year-old boy who had sustained buckshot wounds of both legs when he was caught stealing chickens. An 18-month-old boy had suffered extensive soft tissue injury of

the thigh while in the arms of his mother, who was killed with an axe. An 8-year-old girl came in for revision of a midhumerus amputation stump. She had been run over by a train at age 17 months. There were 12 complications, 11 wound infections, and 1 case of aspiration pneumonitis.

Abdomen.—Forty-seven patients were treated for abdominal injury. Eighteen were observed after blunt trauma but no exploratory operation was performed. Laparotomy in 23 patients revealed ruptured spleen (7), ruptured kidney (5), retroperitoneal hematoma (5), ruptured liver (3, 1 in patient with subdural hematoma who died, 1 due to birth injury), ruptured jejunum (2), intramural hematoma, duodenum (1), and perforation of ileum from gunshot wound (1).

Two of the 6 lacerations of the abdominal wall were deliberate knife wounds. Three patients had been kicked by horses. A 3-week-old Negro boy had sustained perforations of the ileum from a stray bullet when his mother was shot to death by his father. Three children were admitted with evisceration, after injury by an exploding soft drink bottle, a broken beer bottle, and a pencil. The last two were deliberate injuries by playmates.

There were 3 postoperative complications, 1 case of evisceration, and 2 cases of aspiration pneumonitis.

Bites.—Nineteen children were treated for various kinds of bites. Fifteen patients had been bitten by venomous snakes. One infant had suffered extensive injury with actual loss of soft tissue from multiple rat bites. Another child had been bitten by a jealous sibling. Massive edema followed an unidentified insect bite in 1 child. A boy had a severe local reaction after being finned by a catfish.

Rectal Injuries.—Three children had sustained rectal injuries. A 3-year-old white girl had suffered extensive third degree tears due to rape, and a 16-month-old Negro girl sustained rectal and perineal lacerations when an older sibling attempted to take a rectal "temperature" with a large stick. Transverse colostomy was performed in a 3-week-old male with a traumatic rectourethral fistula which had occurred after cystoscopy.

GROUP VII. UMBILICAL HERNIA

Ninety-two patients were treated for umbilical hernias (Fig. 8). Because of the reported tendency of these hernias to close spontaneously, most umbilical hernias are measured periodically. Operation was performed if the hernia was very large or had incarcerated, or when the patient had reached the age of 6 years.

Nineteen patients were admitted with an incarcerated umbilical hernia or a history of previous incarceration. Emergency operation was necessary in only 5 patients, one of whom had a Richter's hernia with gangrene of the ileum which necessitated resection of the terminal ileum and cecum.

Four patients also had repair of a supraumbilical hernia. One was an incisional hernia at the site of a supraumbilical cut-down for exchange transfusion.

Ten complications included 7 hematomas, 2 wound infections, and 1 cardiac arrest in a 20-month-old infant successfully treated by cardiac massage. Only 1 patient is known to have had a recurrence.

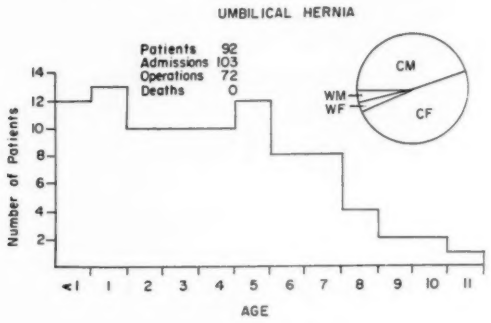

Fig. 8.

GROUP VIII. TUMORS

Eighty-four patients were admitted for neoplasms (Fig. 9). There were 3 deaths on the Surgical Service.

Malignant.—Fifteen patients had malignant tumors. One died during operation and one other died on the Surgery Service. Six additional patients have died at home or on other services.

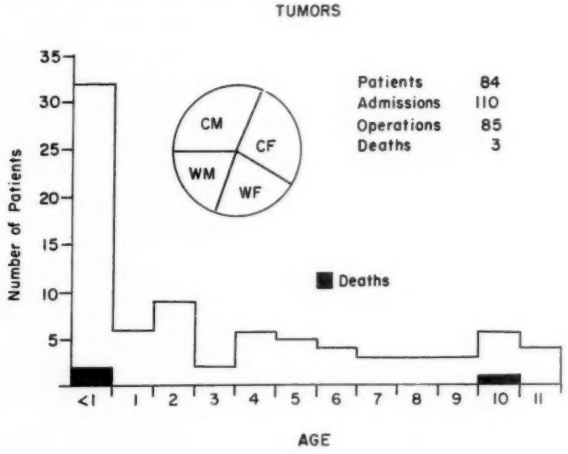

Fig. 9.

Wilms' tumor: Wilms' tumor was found in 3 patients, 2 of whom have died. (Most of these tumors are treated on the Urology Service.)

Neuroblastoma: This tumor occurred in 3 patients, in the area of the celiac plexus, in the adrenal area, and in the chest wall presumably metastatic from the adrenal. Resection was impossible in these patients and all have died.

Hepatoma: Two patients had hepatomas, a 7-month-old boy who died during partial right hepatic lobectomy and a 10-year-old girl whose extensive lesion was only biopsied and who is still living with extensive disease 3 years later.

Lymph node biopsy was performed in 2 patients with retinoblastoma (1 died) and 1 with a fatal reticulum cell sarcoma. A 6-year-old girl had an

adenocystic basal cell carcinoma removed from the face and has been well for 3 years. Two recurrences of a paraganglioma were removed from the scalp of a 9-year-old boy when parents refused radical operation. Three years later he still has tumor of the scalp. A 6-year-old girl with undifferentiated metastatic carcinoma in a subcutaneous mass in the arm is well 4 years later. The possibility of a laboratory error cannot be excluded. A 2-year-old boy came in for revision of an arm amputation which he had undergone at the age of 1 month for neurofibrosarcoma. He is still well 4 years later.

Benign.—Sixty-nine patients were treated for benign tumors. One died after operation. Hemangiomas, lymphangiomas, and cystic hygromas were the most common lesions, and although they might be considered congenital anomalies, they are included as tumors because the pathology and treatment are essentially those of neoplasms.

Hemangioma: This tumor occurred in 26 patients. Operation was not carried out on most of them because it was thought that spontaneous sclerosis would occur. Those treated operatively usually had undiagnosed masses, but in some they were excised because of location (for example, diaper area).

Cystic hygroma and lymphangioma: Nineteen patients had these tumors. In 3, lymphangioma involved an entire extremity. After attempting staged excision of one of these extensive lesions, we abandoned this treatment, and now areas of tumor are excised only if they are bulky and interfere with clothing or function.

Three cystic hygromas were cervical and 6 were in or near the axilla. There was one each in the parotid, lip, anterior abdominal wall, inguinal, retroperitoneal, forearm, and leg regions. The only death in patients with benign tumors occurred after resection of a small axillary cystic hygroma in a 3-week-old infant who died of diarrhea, septicemia, and hepatitis 13 days after operation.

Polyps: Polyps of the rectum and colon were removed sigmoidoscopically or by laparotomy in 8 patients. One child, aged 5, had typical Peutz-Jegher's disease.

Focal nodular hyperplasia: This condition of the liver necessitated left hepatic lobectomy in an 11-month-old girl.

The remainder of the benign tumors were lipoma (4), nevus (4), neurofibroma (3, 2 plexiform), fibroma (1), oral papilloma (2), and giant cell tumor, tendon sheath (1). Fourteen postoperative complications included 8 cases of serum and lymph collection after excision of a cystic hygroma or lymphangioma, 2 wound infections, 2 cases of pneumonitis, and 2 of bronchiolitis.

GROUP IX. SMALL MASSES

Seventy-four patients were treated for small non-neoplastic, noncongenital masses, usually subcutaneous (Fig. 10). Most of these lesions were excised under general anesthesia, even though they were small and superficial. Lack of cooperation in a small child makes operation difficult under local anesthesia, and psychic trauma makes it undesirable. The small masses found are shown in Table III.

TABLE III

MASS	NO.	
Ganglion	22	
Popliteal		11
Wrist		7
Foot		3
Finger		1
Lymph node	14	
Submental		7
Cervical		3
Axillary		2
Subparotid		1
Occipital		1
Granuloma	13	
Foreign body		5
Pyogenic		4
Postinjection		3
Granuloma annulare		1
Keloid	9	
Ear, postpiercing		3
Postburn		3
Posttraumatic		2
Postoperative		1
Organized hematoma	3	
Inclusion cyst	3	
Prepuce		2
Anal gland		1
Condyloma acuminata	2	
Prepuce		1
Anal		1
Ranula	2	
Muscle biopsy	2	
Fat necrosis, thigh	1	
Male breast (healed trauma)	1	
Female breast (not excised)	1	
Verruca vulgaris	1	

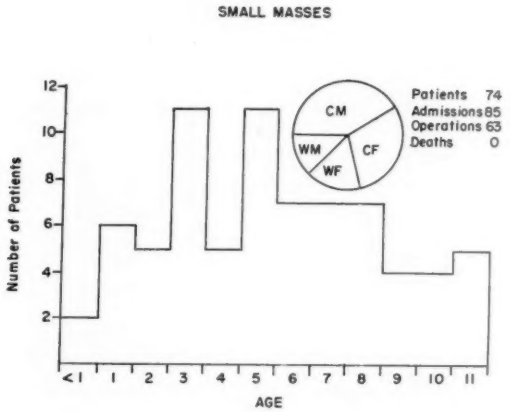

Fig. 10.

GROUP X. ANAL AND RECTAL CONDITIONS

Thirty-one patients had complaints involving the anus and rectum (Fig. 11). There were 18 cases of severe constipation, 4 requiring rectal biopsy to rule out Hirschsprung's disease.

Seven patients had small amounts of rectal bleeding, 5 had anal fissures, but only 1 required excision. Five patients had rectal prolapse. One child was admitted for excision of a large symptomatic anal tag.

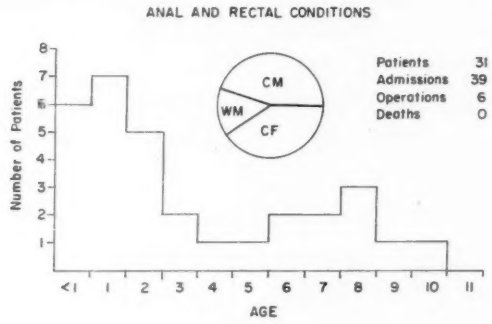

Fig. 11.

GROUP XI. INTESTINAL OBSTRUCTION

Of the 26 patients admitted with intestinal obstruction, 5 died (Fig. 12). (This group does not include 62 patients with congenital obstruction listed under congenital anomalies, 1 with an intramural hematoma of the duodenum listed under trauma, and 12 patients with adhesions listed in other classifications.)

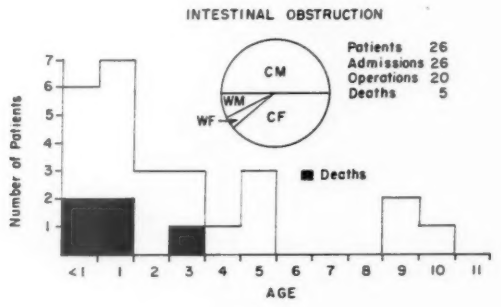

Fig. 12.

Ascariasis.—Thirteen children had obstruction due to massive infestation with ascaris. Six required laparotomy and enterotomy but 6 others were successfully treated with nasogastric suction and piperazine. A 20-month-old infant died shortly after admission for ascaris obstruction with gangrene of the small bowel.

Adhesions.—Four patients had obstruction due to postoperative adhesions. Three had undergone exploratory operations for ascaris obstruction elsewhere. The fourth, a 14-month-old boy, died after lysis of adhesions which developed after transplantation of the ureters on the Urology Service. Obstruction due to postoperative adhesions also occurred in 5 patients after appendectomy, in 2 after exploratory operation for biliary atresia, and in 1 each with incarcerated hernia, sepsis and ileus, malrotation, omphalocele, and chylous cyst.

Intussusception.—There were 6 cases of idiopathic intussusception, 4 ileocolic, 1 colocolic, and 1 ileoileal. One additional patient had intussusception

due to an intramural duplication of the ileum. A 3-month-old infant with an ileoileal intussusception died 13 days after operation with peritonitis and gangrene of the ileum and the abdominal wall.

Other Causes of Obstruction.—There were 3 other causes of obstruction. A 3-month-old baby had resection of gangrenous jejunum which had herniated through a rent in the omentum. A 1,350 gram premature infant died of obstruction due to inspissated milk residue (casein?) impacted in the large and small bowel. A 3-year-old male who had had pyloric stenosis in infancy died after gastrojejunostomy for idiopathic muscular hypertrophy of the duodenum and upper jejunum.

GROUP XII. FOREIGN BODY INGESTION

Twenty-five patients were admitted with a history of having ingested a foreign body (Fig. 13). A 4-inch hat pin, a large open safety pin, and a trichobezoar were removed operatively. The patient with the latter came in with hematemesis due to a gastric ulcer.

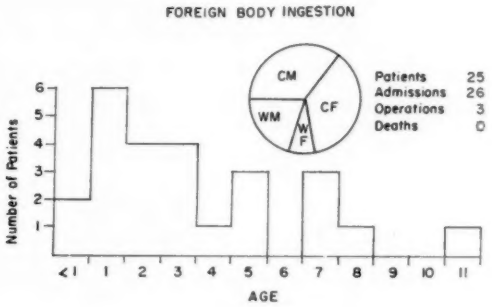

Fig. 13.

The ingested foreign bodies were straight pins (6), broken glass (3), nails (2), safety pins (2), nickels (2), hat pin (1), bobby pin (1), hair pin (1), metal ring (1), carpet tack (1), wing nut (1), china fiddle (1), pecan (1), broken razor blade (1), and hair (trichobezoar) (1).

GROUP XIII. MISCELLANEOUS

Fifty-one patients had conditions not classifiable in any of the previous categories (Fig. 14). Eight died.

Abdomen.—Thirty-eight patients had miscellaneous abdominal conditions. Eight died.

Gastrointestinal hemorrhage: Gastrointestinal bleeding occurred in 5 patients (not including the patient with trichobezoar listed under foreign body ingestion). No diagnosis was made at laparotomy in 4 patients. A 10-year-old boy had anemia and occult blood in the stools 3 years after portacaval anastomosis. He died 2 years later (on the adult service) after partial esophagectomy and colon transplant.

Peptic ulcer: Peptic ulcers occurred in 4 premature infants weighing 2 to 3 pounds. All died. One had a bleeding gastric ulcer, 1 a bleeding duodenal ulcer, and 2 had perforated duodenal ulcers.

Gastrostomy: This was carried out for feeding in an infant with craniostenosis. He died of pneumonitis and atelectasis 3 days after operation.

Acute granulomatous inflammation: Such inflammation of the lungs and reticuloendothelial system caused the death of a 2-year-old boy 3 months after liver biopsy. A fecal fistula had developed in the incision 2 months after operation.

Gangrene of the ileum: Gangrene due to volvulus without malrotation had been found in a newborn who had undergone exploratory operation elsewhere. He had been transferred to Charity Hospital because of a fecal fistula and died shortly after ileotransverse colostomy.

Acute suppurative pancreatitis: This condition and subdiaphragmatic abscess were found at autopsy in a 5-year-old girl who died 24 hours after operation. A 10-hour history of abdominal pain and vomiting had led to exploratory operation, which revealed retroperitoneal edema and fat necrosis.

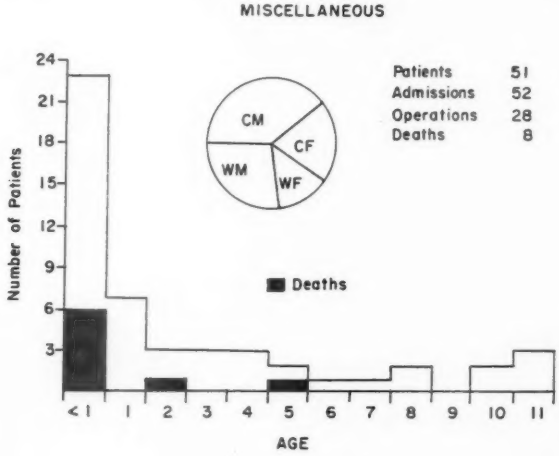

Fig. 14.

Splenectomy: Splenectomy was performed in a 4-year-old boy with sickle-cell disease because the large spleen was thought to be the cause of abdominal pain. Other abdominal conditions were vomiting, improper feeding (6), urinary tract diseases (5), paralytic ileus, pneumonia (4), negative exploratory laparotomy (3, 1 possible tumor, 1 possible ruptured liver, and 1 possible obstruction), neonatal hepatitis, possible biliary atresia (1), hemorrhagic ovarian cyst (1), incisional hernia (1), abdominal hernia, postpolio (1), possible Peutz-Jegher's disease (1), and right upper quadrant hernia (1).

Other Miscellaneous Conditions.—Thirteen patients were admitted with other conditions. These included sternocleidomastoid tumors (4), circumcision (3, 1 recurrent phimosis after clamp circumcision), thyroid enlargement (2), transmetatarsal amputation, gangrene (1), recurrent parotitis (1), hyperostosis, mandible (1), and venous hum, investigation (1). An 11-year-old girl developed hypothyroidism after subtotal thyroidectomy for struma lymphomatosa, and an 8-year-old girl with a mildly tender thyroid has been lost to follow-up.

SURGERY OF THE NEWBORN INFANT

A total of 112 operations were performed on the 110 newborn infants in this report. There were 41 deaths, a mortality rate of 37 per cent. These patients comprised 6 per cent of the total patients and accounted for 70 per cent of the total deaths.

For purposes of this report, a newborn infant is defined as any patient less than 31 days of age or any premature infant of less than normal birth weight still in the premature nursery.

Congenital Anomalies.—Twenty-nine of the 63 patients with gastrointestinal anomalies died. One of 3 patients with multicystic kidney died after nephrectomy and 1 Siamese twin died after operation.

Inguinal Hernia.—Twelve infants with inguinal hernia all survived. Six had incarcerated hernias and 6 were premature infants still in the premature nursery.

Infection.—Of the 14 patients with infection, 1 died of tetanus neonatorum and 2 of sepsis and ileus.

Trauma.—Three infants survived traumatic lesions, rectourethral fistula following cystoscopy, gunshot wound of the abdomen, and rupture of the liver from birth trauma.

Tumor.—A 3-week-old infant died of diarrhea, septicemia, and hepatitis 13 days after excision of a cystic hygroma.

Intestinal Obstruction.—A 1,350 gram infant died after operation for intestinal obstruction due to inspissated milk residue impacted throughout the intestinal tract. This condition, which is usually fatal, has been seen in other premature infants not included in this report.

Miscellaneous.—Five of the 9 patients with miscellaneous conditions died. Four premature infants weighing 810 to 1,610 grams died with bleeding or perforated ulcers of the stomach or duodenum. Operation had been performed in only 2. A full-term infant died after ileotransverse colostomy for volvulus and gangrene of the ileum without malrotation.

COMPLICATIONS

In the total of 1,478 operations, there were 141 complications, an incidence of 9.5 per cent. The rate was higher after emergency operations (11.7 per cent) than after elective operation (7.5 per cent).

Wound Complications.—These were seen in 112 patients. The most common was wound infection, usually after operation in an infected area (appendectomy) or in contaminated wounds (lacerations and bowel surgery). Nearly half of the infections in laparotomy wounds other than those for appendectomy occurred in newborn infants, implicating the umbilical cord and the unhealed umbilicus as a source of contamination.

Postoperative infection was responsible for the death of a 3-month-old infant with intussusception. Operative decompression of the small bowel was thought to be the cause of wound infection with progressive gangrene of the entire thickness of the abdominal wall.

Hematoma and serum collection occurred in 32 patients, usually after operation involving a preformed space or an area of dissection which left a dead space (inguinal and umbilical hernioplasty, excision of cystic hygroma). Bleeding from the wound necessitated additional sutures in 5 postappendectomy patients.

Evisceration occurred in 5 patients, 2 newborn infants, 2 patients with biliary atresia, and 1 child with a laceration of the abdominal wall. One of the patients with biliary atresia survived biliary exploration but evisceration occurred and he died after lysis of adhesions 4 months later.

Incisional hernia was noted in 6 patients. One underwent hernioplasty, but in 2 others the hernia closed spontaneously. Three patients have been lost to follow-up.

Pulmonary Complications.—These occurred in 19 patients, not including 39 newborn infants. Postoperative pneumonitis or atelectasis in 13 children was usually due to aspiration of vomitus, and bronchiolitis in 6 was thought to be due to respiratory infection unrecognized at the time of operation.

A 5-month-old infant with craniostenosis died of atelectasis and pneumonitis 3 days after a feeding gastrostomy, and a 14-month-old boy who had evisceration after transplantation of the ureters for exstrophy of the bladder (by the Urology Service) died with pneumonitis after lysis of adhesions and drainage of a pelvic abscess.

Gastrointestinal Bleeding.—Such bleeding was seen in 1 small infant after the third laparotomy for obstruction due to adhesions and in 2 children after appendectomy.

Cardiac Arrest.—Cardiac arrest in 5 patients has been discussed in the section on anesthesia.

COMMENT

The mortality rate of the total group of 1,799 patients was 3.2 per cent. As far as mortality rates are concerned, newborn infants are the most important group, since 41 (70 per cent) of the total of 59 deaths occurred in these patients.

In evaluating the mortality rate of newborn surgery patients, prematurity and multiple anomalies must be taken into consideration. The over-all mortality rate of newborn patients with major surgical diseases (10 of whom died without operation) was 45 per cent (Table IV). The mortality rate was 28 per cent in patients over 4 pounds without other anomalies and 100 per cent in those under 4 pounds with multiple anomalies.

Nine of the newborn patients who survived and 30 of those who died had serious pulmonary complications, an incidence of 42 per cent. Pneumonitis and atelectasis in these patients is due to the very poor cough reflex of newborn infants which permits aspiration of saliva, milk, nasopharyngeal secretions, and vomitus.

Aspiration can be reduced by frequent nasopharyngeal suction and by gastrostomy. The suction, which stimulates coughing and crying, is accomplished with a small, soft rubber catheter attached to a suction machine regulated to 7 or 8 inches (mercury) of vacuum. This negative pressure is effective in

TABLE IV. MORTALITY RATE OF NEWBORN INFANTS WITH MAJOR SURGICAL CONDITIONS

	PATIENTS	LIVED	DIED	MORTALITY RATE (%)
Over 4 pounds, no other anomalies	66	48	18	28
Under 4 pounds, no other anomalies	8	2	6	75
Over 4 pounds, other serious anomalies	13	2	11	85
Under 4 pounds, other serious anomalies	6	0	6	100
Total	93	52	41	45

removing secretions without causing bleeding. Gastrostomy, which adds little to the operating time, is performed in all cases of congenital small bowel obstruction. A No. 16 mushroom catheter provides adequate decompression but obviates the increased nasopharyngeal secretion produced by a nasogastric tube.

Of the 112 operations performed in newborn infants, only 12 were elective. In contrast, nearly 60 per cent of the operations in older children were elective. Since a condition to be treated electively denotes no immediate threat to the life of the patient, the risk of anesthesia and postoperative complications must be considered.

Of the 18 deaths in this series in patients over the age of 1 month, 12 were not preventable. There were 5 deaths due to postoperative complications, only 1 after elective operation (gastrostomy in an infant with craniostenosis). The 1 death in which anesthesia was incriminated occurred in a child with a malignant neoplasm which would have been fatal without operation.

SUMMARY

A specific diagnosis is listed for each of the 1,799 pediatric surgery patients treated by a university service in a large general hospital for a 5-year period. The complications and causes of death are discussed. Reduction in mortality rate will depend largely on improved knowledge and care of newborn surgery patients.

Surgical History

CONDUCTED BY JOHN R. PAINE, M.D.

DR. BERNHARD ASCHNER: SURGEON, SCIENTIST, AND SCHOLAR

(1883 to 1960)

KAREL B. ABSOLON, M.D., MINNEAPOLIS, MINN.

(From the Department of Surgery, University of Minnesota Medical Center)

ONE of the unusual physician-scientists of the twentieth century died in New York on March 9, 1960. Dr. Bernhard Aschner (Fig. 1), who had started his career as a surgeon, became a pioneer in the field of endocrinology, contributed to studies on arthritis, was a noted medical historian, and attempted to restore certain traditional therapeutic procedures to modern medical practice by establishing the "constitutional therapy."

Aschner was the author of 174 scientific publications, including 14 books. His first two original observations, made between 1908 and 1912, will remain always as medical classics. These concerned the experimental demonstration of the growth and sexual development producing effect of the pituitary (Fig. 2). The discovery of the oculocardiac reflex (Aschner's phenomenon) was another first—a simple but very astute observation. He found that pressure on the eyeball produced bradycardia by a physiologic mechanism in children and in adults with vagotonia.

Aschner was born on Jan. 22, 1883, in Vienna. He obtained his training in medicine at the University of Vienna and received his M.D. degree in 1907. After serving as demonstrator in anatomy under Zuckerkandl, he entered von Eiselsberg's surgical department.

Aschner thus began his medical career with the avowed purpose of becoming a surgeon. The years of surgical assistantship in Vienna were supplemented for young surgeons with inquiring minds with experimental surgical and physiologic investigations. Paltauf, the Chief of the Department of Experimental Pathology, cooperated with Eiselsberg in this program. Aschner's work on the fading of the radial pulse upon ocular compression was an enterprise which emanated from both the Department of Surgery and the Department of Experimental Pathology.

The necessity of obtaining a protracted and broad background of training could have suited only a humble and dedicated man. The apotheosis of medical science, to young Aschner, was achieved by the translation of scientific experiments into practical therapy and vice versa. His extensive experimental

studies in animals, which documented the oculocardiac reflex, stemmed from the observations he had made on anesthetized patients while assisting von Eiselberg, Wagner von Jauregg, the Professor of Psychiatry, also helped instigate the studies, for it was he who had previously shown Aschner at student bedside teaching rounds how a stuporous mentally ill patient could be aroused by pressure on the eyeball.

The development of Aschner's technique of hypophysectomy stimulated Harvey Cushing, who had been unable to obtain long-term survivals after removal of the pituitary in dogs. On one of Cushing's European visits to Eiselsberg's clinic, he learned from Aschner the intricate operative procedure and was able later to adapt his own technique on dogs to the rapidly developing field of neurosurgery.

Fig. 1.—Dr. Bernhard Aschner (1883 to 1960).

Aschner, a cofounder of experimental endocrinology (Fig. 2), recognized its clinical value. Combining his surgical skill developed under Eiselsberg with his interest in endocrine problems, he entered the gynecologic clinic of Schauta in Vienna. In 1912, he accepted the invitation of Veits to become Assistant in the Gynecological and Obstetrical Department in Halle, Germany. In 1913, he was appointed Professor. During World War I, Aschner was awarded the Knight's Cross of the Maltese Order and the Knight's Cross of the Order of Franz Joseph for directing the surgical field unit of the Austro-Hungarian Army in Innsbruck.

After the world-wide turmoil had ended, Aschner was called to the Allgemeine Krankenhaus in Vienna as Docent of Gynecology and Obstetrics. Aschner taught "conservative" surgical intervention and decried the often unnecessary hysterectomies and ovarectomies performed by his colleagues.

He developed a procedure for conservative enucleation of fibroids. From this period of his activity came his books, *Endocrine Diseases of the Female* in 1918, *The Constitution of the Female and Its Relationship to Obstetrics and Gynecology* in 1924, and his contributions to von Halban and Seitz's *Handbook of Gynecology* on the "Relationship of the Endocrine Glands to the Female Genitalia."

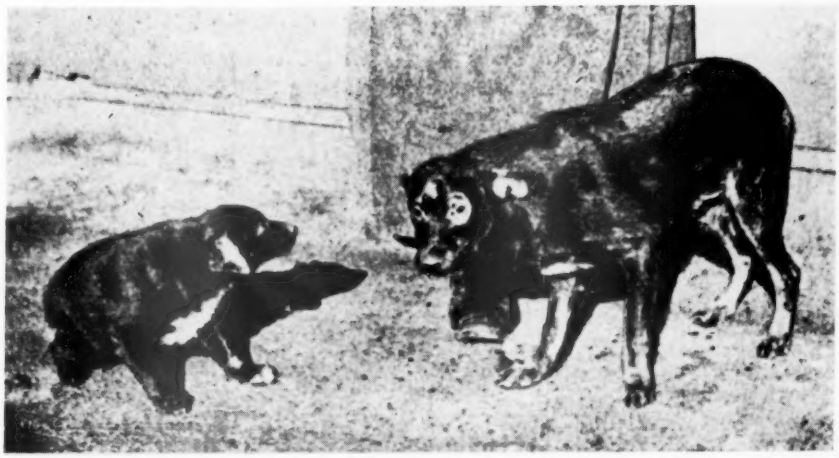

Fig. 2.—Aschner's demonstration of the growth function of the pituitary gland in dogs. The dogs are litter-mates at the age of 4 months. The one on left was hypophysectomized shortly after birth.

The relationship of the endocrines and of the endocrine cycle of pregnancy to arthritis did not escape Aschner's fine clinical sense. It was, therefore, not surprising that he expanded his interests into this area.

Hitler's occupation of Austria in 1938 terminated his academic career. Aschner finally escaped and found his new home in New York. Financially

pressed, he started a new career. He was able to develop a large private practice and directed the arthritis clinics of the Stuyvesant and Lebanon Hospitals.

Aschner enriched the medical literature by translating the works of Paracelsus into modern German (Fig. 3). Even if this should have been his only accomplishment, the monumental 4-volume study with commentaries, which is the most complete treatise on this medieval genius, would have established Aschner as one of the great students of the history of medicine in our time. Dr. H. Sigerist, Professor of History of Medicine at Johns Hopkins University in Baltimore, evaluated this contribution on the occasion of Aschner's seventieth birthday by saying, "Aschner plunged into the old medicine not for mere curiosity, not for cultural interest, but in order to learn."

PARACELSUS

SÄMTLICHE WERKE

NACH DER 10BÄNDIGEN HUSERSCHEN GESAMTAUSGABE
(1589—1591) ZUM ERSTENMAL IN NEUZEITLICHES
DEUTSCH ÜBERSETZT

MIT EINLEITUNG, BIOGRAPHIE, LITERATURANGABEN
UND ERKLÄRENDEN ANMERKUNGEN VERSEHEN

VON

DR. BERNHARD ASCHNER
PRIVATDOZENT IN WIEN

ERSTER BAND

MIT EINEM BILDNIS

JENA
VERLAG VON GUSTAV FISCHER
1926

Fig. 3.—Title page of Aschner's biography of Paracelsus, a translation and analysis of his works.

In the first decades of this century, when Virchow's cellular pathology permeated medical thinking, Aschner emphasized that many morbid conditions are better understood by humoral pathologic explanations, expressing his views in 1931 in the book, *Crisis of Medicine*. He attempted to find a middle

way between empirical therapy and rational therapy as perpetrated by Hippocrates, Galen, Sydenham, and Boerhave. The textbook of *Constitutional Therapy* expresses these ideas. Aschner claimed good results from certain procedures such as venesection and elimination. What tempted this man, in the twilight of his life, to stand so far outside our present-day position on therapeutics is difficult to explain. Aschner admitted that psychosomatic considerations are an important adjunct in his and any kind of therapy.

It is not surprising that the "last of the poly-historians," whose medical activity spanned classic scientific discoveries, historical treaties, surgical, gynecologic, and obstetric activity, and some outlived "historical therapeutic methods," was commonly criticized and attacked. Aschner's contributions were recognized in the Wilhelm Hufeland Award which he received in 1957 in Germany.

After his demonstration of the master endocrine role of the pituitary gland, Aschner's medical career was at first laid out for the pursuit of academic and scientific positions. Aschner believed that "scientific" medicine does not have all the solutions for our "biological microcosmic units" progressing in the "macrocosmic milieu exterieur." He saw no reason why empirically proved therapeutic procedures, tested by centuries of tradition, should not be applied. "Where is a better cardiac drug than digitalis?" he would ask himself. Aschner and Paracelsus, whom he understood so well, could have had the same motto: "Alterius not sit qui suus esse potest" (Nobody else's serf should be, who can stand on his own feet).

Surgical Education and Training

PANEL DISCUSSION ON SURGICAL EDUCATION

DR. J. ENGLEBERT DUNPHY, PRESIDING

DR. DUNPHY.—We might as well proceed with this afternoon's panel on Surgical Education. It is a tradition of this Society to be interested in this topic and I suppose that when the history of surgical education is written in this country, the role of this Society in it will be a very substantial one. Twenty-one years ago, when the Society was first getting under way, it seems to me that we were in a very favorable position. The universities were taking a steady look at the problem of surgical education and training. The problems were not nearly as complex as they seem to be today and at a time when I think this Society and the universities might have influenced an art in surgery in an extraordinarily favorable way, the war came and the hurly-burly of the war and the aftermath of the war I believe had a very unfavorable impact on surgical education. It put the emphasis on surgical training rather than on surgical education and it tended to make the Board of Surgery, which was designed as an examining body interested only in certifying the people who had some reasonable background and some basic knowledge of the subject, in the position of seeming more and more to be a body which was trying to control education and training.

As we look at the problem today, I think we are in a good position to start again from this point. We have a great deal to accomplish and we are going to touch today on two of the issues which deserve careful consideration: (1) What is the role of research in surgical training, what should it be? We know what it is in the university atmosphere. That does not pose so much of a problem, but (2) consider that there are nearly 400, or 500 approved residencies in this country. How much should surgical research be incorporated into their programs? These are very important questions and this Society is one that is going to have to consider the problem. Another aspect of the situation is the volume of clinical material. Economic changes, a number of factors have had an adverse influence on this aspect of surgical education and training and these two subjects will be discussed today. I do not think we will reach any firm decisions. I hope that after the presentations all of you will feel moved to speak.

Our first speaker, Dr. Harkins, is grounded in Chicago and will not be with us this afternoon. Fortunately, his visiting professor, Professor Phillip Sandblom from Lund, Sweden, is here, and while he will not actually represent Dr. Harkins he will comment later on in the program; so we will begin this afternoon's discussion by a sort of combined topic, "The Growth of Research in Surgical Training; The Experience in Minnesota," and Dr. Wangensteen will open the discussion.

Held at the Twenty-first Annual Meeting of the Society of University Surgeons, Minneapolis, Minn., Feb. 11, 1960.

THE MINNESOTA EXPERIENCE IN SURGICAL GRADUATE EDUCATION

OWEN H. WANGENSTEEN, M.D., MINNEAPOLIS, MINN.

(From the Department of Surgery, University of Minnesota Medical School)

IT IS indeed a pleasure for this University to play host to the Society of University Surgeons on this your Twenty-first Anniversary. You were the first group to offer young surgeons the opportunity of being heard. Over a period of many years, you have radiated an influence which has been good for young surgeons and which too has been an important stimulus to American surgery.

We of this Medical School are grateful that over the years you have admitted to membership in this distinguished body so many of our surgeons in their formative years, which has afforded them the opportunity of hearing surgical papers of a high order of merit and of participating in your scientific sessions. We hope that some of you during your stay with us will walk about our wards and laboratories and talk with some of our bright young surgical fellows and interns. Prowl about if you like, but do not be surprised if in your looking around you find young surgeons in the budding stage, sprouting out of broom closets and other places. As far as I can know, the majority of our men in training are reasonably happy and not likely to be led or charmed away by a casual Pied Piper.

About you, you will see something of our University and Medical School. The real University and Medical School, however, are not the buildings you see—some of which are new and others in the process of being built—the real University is to be found typified by the labors of the young men, whose presentations you will hear today. These men, like yourselves, are interested primarily in the advance of surgery.

The content of your program is not one that would have been appreciated or excited the understanding of many surgeons three decades or more ago. You are remaking surgery and helping to establish the unique combination of art, science, and the skills of surgeons, through the agency of research, as one of the strong arms of progressive medicine, worthy of the respect of faculties and of the people from whom our support comes. We hope that your meeting here and the celebration of your coming of age will continue to augur well for even greater gains and growth of American surgery.

SURGICAL FELLOWS

The thing that is unique concerning our residency scheme of training at the University of Minnesota is an affiliation between Medical and Graduate Schools,

Read at the Society of University Surgeons, Feb. 11, 1960. Minneapolis, Minn.

for graduate education and training. You will be interested in knowing that our first Ph.D. granted in Surgery was to Dr. G. L. McWhorter in 1917. Many of you will recognize his name as having been identified with Rush Medical School in Chicago for long years.

Affiliation of our Medical School with the Graduate School was effected in 1914. In the intervening years, 839 Surgical Fellows have been registered in the Graduate School from this Department. Of these, 35 per cent came from the University Hospital; 15 per cent from the Veterans; 12 per cent from the Minneapolis General; 5 per cent from Ancker Hospital (Municipal Hospital in St. Paul); and the others from a number of combinations of these various hospitals. The majority of these Fellows have been in General Surgery. In more recent years, however, several have earned graduate degrees in the Surgical Specialties of Neurosurgery, Orthopedics, and Urology. Anesthesia for many years was a Division of the Department of Surgery but has enjoyed departmental status now since 1954.

ADVANTAGES OF BEING A BONA FIDE GRADUATE STUDENT

In earlier years, when my friends asked me about the advantages accruing from an affiliation with a Graduate School, I found it difficult sometimes to supply satisfying answers. However, after many years of experience with the situation, I believe I can give answers which at least are satisfying to me. On the one score, what appears to be a disadvantage works out to be an enormous advantage. I allude to the circumstance that the Fellow gets his monthly stipend by virtue of registration in the Graduate School. Registration signifies the intent of pursuing study leading to a graduate degree; but inasmuch as during these years we have had only 75 Ph.D. degrees awarded and 82 M.S. degrees, you can see that every man did **not** fulfill his intention. However, many a surgical neophyte, like myself, while reluctantly capitulating to satisfying this Graduate School requirement and dreading the very idea of having to work at a problem of research, found in doing so that it excited his interest, alerted his curiosity, and left him with a compelling impulse to continue working away at research. Many of you undoubtedly have stayed in the game, finding that the pursuit of unanswered problems is very satisfying to the soul.

The American language, I feel, stands in great need of a good word to connote transition from rejection to acceptance. It is a common phenomenon with all of us. What seemed like an almost insurmountable obstacle course turned out to be a blessing in disguise.

A number of surgeons protest it is not easy to interest young house officers in going to the experimental laboratory. On that score, I must tell you, our problem here primarily seems to be one of keeping the man out of the laboratory who we feel may waste his own time, as well as ours. Our Surgical Fellows have come to know that if they can get to the laboratory, they will find there the incentive which is most likely to drive them on to accomplishments and objectives which they could not otherwise attain. In the experimental laboratory, they will gain an experience of wrestling with unsettled problems. The

laboratory, while training the young surgeon's hands, simultaneously sharpens his intellect and raises his sights on the distant horizon. Yes, if you are debating such a relationship in your own Medical School, I would say: Persuade the authorities of your Medical School to permit you to effect a liaison with the Graduate School of your University. It is an investment which pays usurious dividends to all participants.

Additionally, there has been another advantage that even the founders of this plan in our School did not foresee. In the usual scheme of surgical training, the resident is paid for service and in consequence pays a proportionate income tax; here, because the Fellow is a graduate student, his stipend is absolved from income tax up to $3,600. This windfall alone in the present nature of things makes the matter look attractive from the standpoint of the Fellow.

SHIFT FROM PART-TIME TO FULL-TIME STAFF

When I became Chairman of this Department in January, 1930, we had a Staff of many part-time clinical surgeons. I was the only full-time member of the Staff. The budget was small and was parcelled out to a large number of Clinical Professors, Associate and Assistant Professors, and Instructors. We had one Surgical Fellow. When I proposed to the incumbent that I thought there was enough work for two, he threatened to resign. After some persuasion, however, I was able to convince him that perhaps even two Fellows could find work enough to do.

In those days, Orthopedics and Urology were represented in the Department as teaching functions only. All surgery, save for a few isolated matters, was done by the General Surgeon. My chief and predecessor, Dr. Strachauer, did all types of surgery, save thoracic surgery. However, we had on the Staff three charter members of the American Association for Thoracic Surgery. Some of you may recognize the names: Drs. James F. Corbett, A. A. Law, and William Lerche. The latter still survives and lives in the skiing area of Cable, Wisconsin, where he probably relives in pleasant recollection the arduous task of climbing up scientific mountains, without the aid of electrically propelled lifts.

It was my hope that we could retrieve some of the funds, spread among many members of our part-time Clinical Staff, to acquire more Surgical Fellows. I began a planned strategy to do this, allowing men to retain their clinical opportunity but severing them from their departmental sources of support. The depression years were on. The economy of the entire country was affected as were all universities. It did not surprise me that news of the displeasure of some of my Staff over these tactics reached the ear of the Dean. Dean E. P. Lyon, to whom I was indebted for my appointment, had approved the plan but had warned me not to move too rapidly. By the Spring of 1933, when the crisis came, my great friend and mentor, Dean Lyon, had retired into the background to deal with the curriculum of the Medical School. The new Dean, Dr. Richard E. Scammon, great teacher and investigator, had assumed the reins of direction for the School without previous real administrative experience. More influenced perhaps than he should have been by the whisperings of my colleagues, it looked

for a period as though the end for me was in sight. I still had several warm friends in the faculty, however, most of whom were content to watch the outcome of the fray from the sidelines. The late Dr. J. C. McKinley, eminent neurologist and then Professor of Medicine, entered the lists actively on my side. My professional neck, I can tell you now, lay extended upon the block for longer than I like to recall, while I waited hopefully for signs of help from a higher level. The guillotine did not descend. Help did come from friends whose support really counted. Ah, bless the memory of great and true friends! Dean Lyon, one of the greatest of the fine Deans this Medical School has had, Lotus Delta Coffman, President of the University, and William J. Mayo, distinguished Regent of this University—these were the men who came to my rescue. Where could one have found better or more effectual support? While this episode came to be labeled the "kindergarten cabal," the issue had to do primarily with a shift of emphasis to more active participation by a young full-time Staff for patient care in the hospital. Dr. Scammon was by general consent the great teacher of our Faculty in my student days. However, it takes other qualities to make a great Dean, including an ability to recognize whisperings for what they are, and a willingness and strength to hold the fort against attacks motivated by self-interest.

As I think back now upon these events, I must confess that the stay of sentence and the confidence which my friends and colleagues then expressed in me has probably been an impelling force which has driven me on to strive to merit the kindly judgment and assurances I then received. In telling you this story which, with another ending, could have meant for me a type of professional life far different from that which has been my privilege these many years, I tell the story too for another reason: to indicate how necessary it is to take a firm stand in vital matters which concern the directional and developmental growth of an activity in which one believes. Had that stand then not been made, it might very well have taken a couple of decades to effect the transition which I felt we must bridge to free ourselves from the thralldom of mediocrity occasioned in part by dissipation of our monies to men who did not need it.

Budgets were small in those days. The total budget for the Department was about $30,000. Despite the depression and through the agency of recovery of some of the Departmental monies through the strategy named, we were able to swell the number of Surgical Fellows from two in 1930 to four, to six, and finally to nine, which number we held until the beginning of our participation in the war. At that time, we were reduced to one Surgical Fellow through the mobilization of Base Hospital 26 and other hospital units which went out from this Medical School and Community.

After the war came the deluge. These have truly been halcyon years for the experimental effort. You may be interested in knowing that three years ago we had fifty fellows in General Surgery alone at the University Hospitals. Today, we have 85. Our Legislative Departmental budget has increased by more than 500 per cent but represents approximately 20 per cent of our total Departmental budget.

You may well wonder what all these men do. I can assure you they are all occupied. Without access to experimental laboratories, however, it would manifestly be impossible to provide them with acceptable training on hospital wards alone.

GROWTH OF THIS UNIVERSITY

This University came into being through Legislative Act in 1851. However, it was in 1869 that our first President, Mr. William Watts Folwell, was appointed, the very year in which C. W. Eliot became President of Harvard. During these intervening years, we have had eight very wonderful men at the helm. It has been my privilege to have known and talked with all of them, and to have walked with most of them. It was George Edgar Vincent, great Chautauqua Lecturer, who came to us in 1911, who consolidated and laid the foundations for great strength in this University. It was he who brought Dean Lyon, Drs. C. M. Jackson, Richard E. Scammon, and E. T. Bell to our Medical School and Drs. Coffman, Coffey, and Ford to the University—who were to succeed one another as Presidents of this University.

The Medical School in my day as a student here, somewhat more than forty years ago, was a rather mediocre affair. However, under Drs. Jackson, Scammon, Hal Downey, and A. T. Rasmussen in Anatomy, the spirit of research got started and slowly spread into other Departments of the Medical School.

The Medical School had come into being in 1889 and like many schools of its kind was distinctly a clinically oriented school, until the coming of George Vincent, who left in 1917 to join the Rockefeller Institute. In six short years, Vincent changed the course of the University. In my student days, one did not need to strain his ears to hear overt evidences of resentment against clinicians interesting themselves in research. One of my teachers was likely to say to a person consulting him concerning the wisdom of engaging in research for purposes of improving his orientation: "Write your way up the academic ladder, if you wish, with a typewriter and a few white rats, but that training will never make you a good doctor."

HOW I CAME TO FOLLOW THE ACADEMIC LINE

My preceptor and predecessor, Dr. Arthur C. Strachauer, resigned in 1925 to engage in full-time surgical practice in the community, on the recommendation of Harvey Cushing, a member of the Harvard Staff came out to be interviewed. It was my privilege to show him around the surgical wards. After looking about and conferring with the authorities, he said in substance to me: "There is nothing worth while here nor will there ever be." Two years went by. Dr. Strachauer consented to resume administrative responsibility for the Department until a successor could be found. In 1927, a candidate from the Johns Hopkins group of surgeons came to be interviewed. He too looked about and assessed the situation very much in the manner that the Harvard man had done two years before. And so it happened that eventually the opportunity came to me to begin the hard but fascinating climb up the academic ladder.

What you see here today is a Medical School somewhat more than sixty years of age. In fact, it will celebrate its centennial in 1989. As I look back now upon a period of more than 35 years of identity with this Department in the role of Fellow and Teacher, definite evidences of growth are unmistakable. The first ten years were made difficult by the long period of the depression; the next five by the contraction, dissipation, and diversion of interest because of the war effort. It was in those fifteen trying years, however, that the real spirit of the Department was being formed and the Medical School, the University, and my clinical part-time and full-time associates came to accept me and my general plan for the development of the Department, for all of which I have been and continue to be very grateful.

It is always a bit embarrassing when a young surgeon at a meeting inquires whether it was your father or your grandfather who first worked with gastrointestinal intubation. While I no longer make a serious effort to take the lead in the hunt, I still like to run with the hounds, and as long as I do not fall so far back that my colleagues begin to worry about me, I intend to stay with the chase. It is a great game—one of the best there is, I believe many of you will agree.

An item which has typified the attitude of our University Administration toward new appointments is apparent in the following. A few years ago, a president of a distinguished Midwest university came to consult Dr. James L. Morrill, President of our University, on the matter of his own Medical School, which, at the time was slipping into the doldrums, when compared with other segments of his University. Said Dr. Morrill on this occasion: "We do not consider positions in the University fixed. When we find a good young man, we are willing to start him on a shoestring, if necessary." Such I had learned from experience was the attitude of Presidents Coffman and Ford. Dean Lyon had been a champion of this attitude in the Medical School and when Dr. Scammon retired from the Deanship in 1935 to devote himself to the completion of his important studies on Growth, his successor in the Deanship, Dr. Harold S. Diehl, supported this policy up to the hilt. I could tell you of a host of young surgeons who got their start this way in this Department. Their names are known to most of you. Those of us who had become established moved over a bit in the shift to divide our opportunity with the men newly appointed to the Staff. And so it must always be, if a Department is to grow. Worthwhile opportunities and support for these men of promise must be sought and found.

SURGICAL BEDS

Since 1930, the number of hospital beds in this Institution has not grown in proportion to the entire operation of personnel and facilities. In a sense, though it was, at times, a source of great concern to me, it was nevertheless probably a blessing in disguise. In the beginning, the entire University Hospital counted only 200 beds, which number was increased by an additional 100 in 1924, and another 100 in 1929. When the Heart Hospital came into being in 1951, another 80 beds were added, and through the coming of the Mayo Memorial,

an additional 150 beds has been added and with the addition of the Masons' Hospital for the study of advanced cancer, we have now in the area of 750 beds. Through affiliations with a number of hospitals in this area, we have a rich clinical material. Acute cases are available for undergraduate as well as graduate teaching in our municipal hospitals—the Minneapolis General and the Ancker in St. Paul. At the Veterans Hospital we have a Staff which in professional and research potential rivals our own. In addition, we have an affiliation with two voluntary hospitals, Mount Sinai in Minneapolis and St. Joseph's Hospital in St. Paul. A condition of affiliation has been that the hospital erect an experimental laboratory, support a full-time Surgical Supervisor, and provide a minimum of ten free beds. This program continues to work well.

The Surgical Service in the University of Minnesota Medical Center, with the new hospital developments, came to have a larger number of hospital beds. Initially (1930) we had 130 to 140, which number shrank over a number of years to about 110, made necessary by contraction of the number of hospital beds to provide laboratory space and offices for full-time members of the Clinical Staff. The new hospital building program has permitted re-expansion of this number to somewhat more than 180 beds. In fact, I believe that we have now about as many beds as our present Surgical Staff conveniently can look after without serious disruption of their other responsibilities.

It is not possible, I believe, for the Head of a Department to be its perpetual hero. Fortunate indeed is that Chief whom his colleagues accept, even though they do not always agree with him. I have told you something of my own early-day struggles in this Department. In fact, I have had the experience of being the youngest member of the Faculty, as well as the oldest. Neither is a particularly desirable role; however, of the two, my experience suggests the latter has a few more compensations.

It has been my policy to run the Department in a decentralized manner. Every man afforded Staff status is autonomous. He need not consult me about what to do or how to do it. I rarely offer gratuitous advice. If it is sought, however, and I feel I can help, I am glad to offer an opinion. Those of us who are full Professors in the Department each have 15 hospital beds at our disposal. My thought has been that none of us should become so absorbed in the care of patients that little time and thought remain for the prosecution of our teaching and research functions and responsibilities.

ROLE OF THE EXPERIMENTAL LABORATORY IN SURGICAL TRAINING

Obviously, we could not manage 105 Surgical Fellows (20 in the specialties and 85 in general surgery) without recourse to adequate laboratory space. Approximately half of our Fellows in General Surgery spend their time in the experimental laboratories. This scheme lengthens the period of training somewhat. In my day, a Ph.D. could be earned in three years. Today, our men who acquire Ph.D. degrees are in their seventh year of training, usually having been made an instructor then or in their fifth or sixth year of apprenticeship. This I believe, more and more will be the pattern of training and development for surgeons in the years ahead.

Some of you may smile at the thought of supporting so many Surgical Fellows on this allotted number of hospital beds. Obviously, we are very dependent upon our experimental laboratories. Moreover, as the years go by, I am inclined to believe that Boards will come to recognize the great importance of these laboratories in the training of surgeons. Even in the case of the man who does not go to the laboratory, we find it takes more than four years to make him a passing good surgeon.

You must believe me when I say that our best surgeons are those who have spent considerable time in the experimental laboratory. Moreover, our very best men in addition are sent to physiology or one of the allied preclinical sciences for a period of a year or more for the acquisition of special techniques and knowledge which they can use to great advantage in the attack upon their own research problems. It is a duteous pleasure to acknowledge before this body of surgeons the great help which this Department has received these many years from Dr. Maurice B. Visscher, Chairman of the Department of Physiology. His imprint and that of his Department are very evident, even on very superficial examination, on many of our men. Twenty-five of our men occupy professorial positions; ten are here, fifteen elsewhere—some of these are Heads of Departments. Eight Markle Scholars have come out of this Department, whose names are known to most of you.

You may be interested in knowing that only eight of the Fellows in General Surgery are supported by the Departmental budget. For the others, together with a few of my associates, I am continually on the prowl for likely sources of support, a responsibility which has put a stretch on my pia mater that has contributed to insomnia, which waking hours I find can be used very profitably as an incentive to letter writing, begging and pleading with organizations and friends, kindly disposed toward Departments interested in fostering a spirit of research.

ROLE OF THE PROFESSOR

The role of the Professor has been defined essentially as that of teacher, surgeon, and investigator. My experience would suggest that two other items for the Heads of Departments should be added: (1) side-line cheerleader and (2) regimental water carrier. My great friend, Dean Lyon, was wont to say the best Dean he knew of was Gunga Din, Kipling's regimental water carrier. Above all these enumerated functions, however, it is my feeling that the most important concern of a departmental head is to create an atmosphere friendly to learning. This must be his chief responsibility. He must have the willingness to recognize every type of talent and ability, and to encourage men of promise.

When I was abroad somewhat more than thirty years ago and visited Continental surgical clinics and those of the British Isles, I searched diligently for evidences of experimental laboratories in use for the training of the surgeon. I found only two: Eugene Enderlen's in Heidelberg, the other that of David Wilkie in Edinburgh. It was Halsted who emphasized the importance of the

laboratory in the training of surgeons. Today, it is far easier to do than it was thirty-five or forty years ago. Monies are available for this purpose and from many organizations and sources. In my opinion, no departmental head today can neglect the experimental laboratory, not alone because of the great stimulus to research efforts which an active laboratory provides, but also because it constitutes an important source of growth, made possible by funds readily available for research. And if the young men working in the experimental laboratories prove to be productive, a continuing liberal source of support through this agency is assured.

The future poses a number of difficult problems which demand solution in medical schools by groups like yours. In my earlier days here, the only private patient in the hospital was a sick nurse or intern. Times have changed. With the growing prosperity of the country which came with the war, and which I would like to believe will persist, some means of reapportioning the financial reward of clinicians will have to be worked out.

On some of the clinical services of this Department, as many as 60 to 80 per cent of the patients operated upon are private patients. It should not be too difficult to persuade the full-time man in surgery that his chief emolument is opportunity and the privilege of being a part of and guiding the destiny of an important endeavor.

The future of our Medical Schools is dependent in large degree upon Clinical Professors remaining faithful to the primary functions and principles of Universities. The University offers the prospective full-time clinician who proposes to follow the academic line the opportunity of making something *of himself*. He must take care not to become too absorbed in making something *for himself*.

Said John Hunter in his day: "It so happens, unfortunately, that those who from the nature of their education are best qualified to investigate the intricacies, and improve our knowledge of the animal oeconomy, are compelled to get their living by the practice of a profession which is constant employment. The only educated men who have leisure are those of the church, some of whom we frequently find commencing philosophers and physiologists, (criticism directed at Abbé Spallanzani) though they have not had that kind of education which would best direct their pursuit."

Today, surgeons in University clinics enjoy opportunities for creative achievement, unprecedented in the annals of Medicine. Opportunity is the great paymaster of the University Surgeon. Society's claim upon University Surgeons, because of the great advantages which are ours, is equivalent to a mandate to enjoy, appreciate, and make the most of our wonderful opportunities, requiting to Society a liberal and just return for our unrivaled privileges. Though the flame of our own lamps may not burn brightly enough to emit luminous light, yet it is comforting and rewarding to know that tending the wicks of the lamps of our associates may succeed in kindling light which can blaze the trails of the future. The Society of University Surgeons and its members must continue to hold to the highest ideals of Surgery and of Universities.

PROFESSOR PHILIP SANDBLOM, LUND, SWEDEN.—I had not expected to step in so suddenly for my chief pro tem., Henry Harkins. The lack of preparation is a good excuse for the simplicity of my remarks. I suppose the reason for my standing here is that the Society of University Surgeons as a learned society wants to know not only the mean, but also the maximum and the minimum, of surgical education. With Dr. Wangensteen representing the former it is appropriate for me to represent the latter. The fact is, which you all know, that medical research in the United States is superior to all. Last summer when I took part in a meeting of American University Presidents I was disappointed to hear one of them complain bitterly about the disproportion between money granted to education and money given to research in American medical schools. He thought that the research was taking far too much of it. There is little doubt that in the United States, medical research takes a greater proportion of the budget than it does anywhere else. By spending so much on medical research the United States however is the absolute leader. This is not only a great help to medicine here and all over the world, but first of all to the American public. They have good reason to be very grateful for what they get for their money.

At this time I should like to express the feeling of deep gratitude as a foreigner for the generosity and kindness with which we are received when we come here to study the advances in medicine. It is a necessity for us to do this. A lot of things you can study by reading, but in medicine, especially in surgery, you also have to study in person.

When organizing medical education there is a great temptation for the state to separate education from research and to favor the former more than the latter as this seems more economical. This is a rather short-sighted point of view. As Dr. Wangensteen so well has showed, it is absolutely necessary for a good medical education to be combined with a fair proportion of medical research. It seems to me that the proportion of those two at Dr. Wangensteen's department comes close to the ideal.

When starting an academic career, the young student is inclined to trust everything he reads in the textbooks, and everything seems simple and straightforward. He gets the impression that if he only learns what is printed everything will be all right. After a few years he understands that he can't trust everything that he reads, he begins to speculate, he finds that he has to examine the statements, and to his great excitement he finds that he has to change some of them and that he himself can contribute to the progress of science. I think those years are the best in the academic career. Sooner or later those happy years pass. Everything changes and you begin to feel that your knowledge is the knowledge of yesterday. As one gets more involved in the administration of the department the time that one can give to research diminishes.

However, it is of the utmost importance for the development of clinical science that the medical leaders should be willing to share the administrative duties and not yield to the temptation to hand this over to professional administrators.

At this point one does best to hand the active scientific work over to the younger generation and help them to all the opportunities. There are some exceptions to this, and I know that the moderator of this symposium is at the same time an excellent administrator and a brilliant active scientist.

I might point out a few small differences between surgical education in Sweden and the United States.

There are hardly any private hospitals in Sweden. The great majority of them are owned by the state or the community. They are all staffed by full-time men. We do not have private practitioners on the staff. We either do surgery all day long or no surgery at all. For this reason we educate a lot fewer surgeons than you do here.

Also, we do not have the resident system you have in the United States. When a young Swedish surgeon starts his career, he first works for one year in the university department. Then he goes out to a provincial hospital for several years to get his technical training. If he turns out to be good, we will take him back into the university hospital where he will stay for at least three or four years. If he contemplates an academic career he will start working on his thesis. There is nothing comparable to being a senior resident. He just goes right on, and he does the large operations at a much later time than the Americans do.

I understand you have some trouble getting clinical material, because more and more patients become private and you do not have the indigent patients for teaching purposes. Sweden has gone just the opposite way. Most patients in Sweden are now indigent, if you want. That is to say, the majority of Swedish hospital beds are still ward beds with a very small per cent of private beds. After this year the surgeons will not even be allowed to receive fees from any hospital patients. It would not be good if the surgeons also become indigent. We still can receive some income from the outpatient department, but surgical progress will certainly not benefit if there should be a temptation for the surgeons to find a greater interest in treating small surgical disorders. It is a regrettable fact that the brilliant young man hesitates to choose a career as a highly specialized surgeon, if he can get an entirely comparable position in other branches of medicine with a considerably shorter training period.

With the tendency to equalize the economic income, society might deprive itself of the possibility of rewarding extraordinary effort, as for example that of a highly specialized surgeon. This in the end will jeopardize medical progress to the loss of society.

DR. DUNPHY.—I would welcome any questions or comments from the audience at this point. Dr. Gerbode.

DR. GERBODE.—I'd like to ask Dr. Wangensteen, when he says Fellows, does he mean all young men who are residents?

DR. WANGENSTEEN.—In this Institution, Dr. Gerbode, the designation, Fellow, is synonymous with the term Resident or Assistant Resident, more commonly used in other institutions. All our Fellows are registered in the Graduate Schools. The majority of our Fellows come from our own Surgical Internship group. There are occasional and notable exceptions. Additionally, we have had a fairly large number especially in recent years who have come from foreign countries. Many of this latter group come to work with our cardiac surgeons.

DR. DUNPHY.— One of the things that has always troubled me a little bit about the Graduate School is the degree when it's given in surgery. It seems to me it is fine to have an M.S. or a Ph.D. in some other discipline, but that we ought to think of the M.D. as including these other disciplines that we are interested in. It's a degree in its own right. I don't know whether you'd like to comment on that or not—a Ph.D. either in surgery or in physiology?

DR. WANGENSTEEN.—The larger number of our full-time Surgical Faculty have Ph.D. degrees in surgery. As I explained earlier in my talk, this program has been in existence in this Department since 1914. There were, however, few degrees awarded until 1930. Mine was the fourth originating in this Department and was earned in the year 1925.

In my early days in this Medical School, a number of persons in many of the departments of this School who were candidates for graduate degrees did their work in Anatomy, because it was the only department in which there was an active research program. Moreover, it was not too difficult to get a Ph.D. in this manner. Drs. Jackson, Scammon, and others had an infinitude of problems for persons to work on. It was my observation that the clinicians who followed that path used it as a convenient means to an end. Rarely did they follow up on the initial effort. Moreover, only rarely did the thesis work constitute an important contribution. Apart from the acquisition of some knowledge of a research technique in another discipline, no real gain accrued to the Department of Surgery in such ventures. My belief has been that the Surgical Fellow should do his thesis work in some aspect of surgery. If we should run out of problems, which does not seem likely at the moment, we could revert to this older principle. Such in any case was the practice in my student days and yours too perhaps. And as you know, there was not much research done in clinical departments in those days.

There is much to be said, Dr. Dunphy, for men spending a good deal of time in a discipline other than surgery. In fact, we are very definitely committed to such a plan here. However, the research problem for the Ph.D. thesis originates within the Department of Surgery. As many of you are aware, many of our best men have spent considerable time in

Physiology. You will find a number of men here like Drs. Paine, Dennis, Varco, Lillehei, and others who satisfied the requirement of the Minor toward the Ph.D. degree by spending a full year or more in Physiology. Dr. John Lewis' training was in Anatomy, that of Dr. George Moore in Zoology, and Dr. Zimmermann had his preliminary training in Biochemistry. Additionally, a fairly large number of our men, through the years, have satisfied the requirement of the Minor by working in Pathology.

We have had, as I have been at pains to point out, a very special arrangement with Physiology, through its Chairman, Dr. Maurice B. Visscher, a very warm, personal friend of more than thirty years. If a Fellow for reasons of his own would select Biochemistry, Biophysics, Microbiology, or some other discipline, we would, of course, encourage him to go there for his contact with one of the preclinical sciences. While our Fellows are at work in these other Departments, it is our responsibility of course to supply the stipends.

Many of our colleagues in the preclinical sciences complain that we are draining off their source of graduate material, which accusation is, in a sense, true. Since World War II, there has been considerable enlivening of the research interest in most Departments of Surgery throughout our country. In earlier years, if an aspirant for a surgical career was to have done research, he would have found it easier probably to have undertaken it in some other discipline.

It has been suggested locally, in fact, that the graduate degree be given in some discipline other than surgery. Personally, I would dislike very much seeing that come about. In fact, I would oppose it. Not all the clinical departments in our School have put the same emphasis upon earning a graduate degree as has Surgery.

If we were to capitulate to the plea that our Surgical Fellows do all their thesis work in another discipline and department of this School, I cannot believe that the interest of the man or of this Department would be served as well as in the present arrangement. I feel it is much better for the Surgical Fellow with the help of his advisor to originate his problem within the Department of Surgery. As his work progresses, and he comes to have a feeling of real orientation in the problem, it is good for him to interrupt his work for a year or more to become a graduate student in that discipline which has been of most help to him in the prosecution of his research. The preclinical scientists in our School, therefore, know and feel the importance of their role in the training and making of our surgeons.

While saying all this, I share the lament of our preclinical colleagues over the diminishing numbers of men pursuing graduate work in those disciplines. In Anatomy, Biochemistry, Microbiology, and Physiology, I presume the only answer is: More Ph.D.'s without the M.D. The contribution of the preclinical Ph.D. scientist to medicine is great and the accomplishment of this important group of teachers and investigators must not be underrated. If, however, the Ph.D. program in this School were to be transferred out of the Department of Surgery to other disciplines, I have the feeling that the research interest in the Department would fall off sharply. The only answer, as I see it, is that our surgeons need to be research minded, and for those desiring to climb the academic ladder additional training in at least one of the preclinical disciplines is essential.

DR. DUNPHY.—Are there any other comments or questions? Well, I will close this part of the program by simply saying that we are very grateful to you, Owen, for this exposition and I am sure that it has been a privilege for the Society to listen to you.

(To be concluded.)